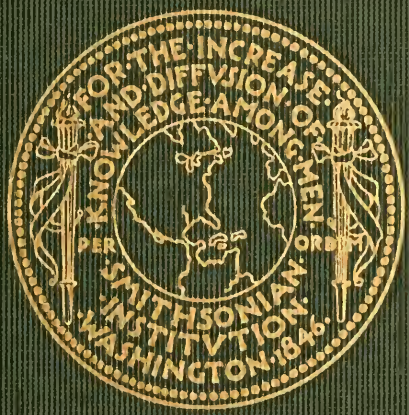

FOR THE INCREASE
AND DIFFVSION OF
KNOWLEDGE AMONG MEN
PER
SMITHSONIAN
INSTITVTION
WASHINGTON 1846

Annual Report of the Board of Regents

of the

SMITHSONIAN INSTITUTION

PUBLICATION 4190

Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30

1954

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1955

LETTER OF TRANSMITTAL

SMITHSONIAN INSTITUTION,
Washington, December 30, 1954.

To the Congress of the United States:

In accordance with section 5593 of the Revised Statutes of the United States, I have the honor, on behalf of the Board of Regents, to submit to Congress the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year ended June 30, 1954. I have the honor to be,

Respectfully,

LEONARD CARMICHAEL, *Secretary.*

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THE SMITHSONIAN INSTITUTION

June 30, 1954

Presiding Officer ex officio.—DWIGHT D. EISENHOWER, President of the United States.

Chancellor.—EARL WARREN, Chief Justice of the United States.

Members of the Institution:

DWIGHT D. EISENHOWER, President of the United States.
RICHARD M. NIXON, Vice President of the United States.
EARL WARREN, Chief Justice of the United States.
JOHN FOSTER DULLES, Secretary of State.
GEORGE M. HUMPHREY, Secretary of the Treasury.
CHARLES E. WILSON, Secretary of Defense.
HERBERT BROWNELL, JR., Attorney General.
ARTHUR E. SUMMERFIELD, Postmaster General.
DOUGLAS MCKAY, Secretary of the Interior.
EZRA TAFT BENSON, Secretary of Agriculture.
SINCLAIR WEEKS, Secretary of Commerce.
JAMES P. MITCHELL, Secretary of Labor.
OVETA CULP HOBBY, Secretary of Health, Education, and Welfare.

Regents of the Institution:

EARL WARREN, Chief Justice of the United States, Chancellor.
RICHARD M. NIXON, Vice President of the United States.
CLINTON P. ANDERSON, Member of the Senate.
LEVERETT SALTONSTALL, Member of the Senate.
H. ALEXANDER SMITH, Member of the Senate.
CLARENCE CANNON, Member of the House of Representatives.
LEROY JOHNSON, Member of the House of Representatives.
JOHN M. VORYS, Member of the House of Representatives.
VANNEVAR BUSH, citizen of Washington, D. C.
ARTHUR H. COMPTON, citizen of Missouri.
ROBERT V. FLEMING, citizen of Washington, D. C.
JEROME C. HUNSAKER, citizen of Massachusetts.
OWEN J. ROBERTS, citizen of Pennsylvania.

Executive Committee.—ROBERT V. FLEMING, *chairman*, VANNEVAR BUSH, CLARENCE CANNON.

Secretary.—LEONARD CARMICHAEL.

Assistant Secretaries.—JOHN E. GRAF, J. L. KEDDY.

Administrative assistant to the Secretary.—MRS. LOUISE M. PEARSON.

Treasurer.—J. D. HOWARD.

Chief, editorial and publications division.—PAUL H. OEHSER.

Assistant chief, editorial and publications division.—JOHN S. LEA.

Librarian.—MRS. LEILA F. CLARK.

Chief, accounting division.—THOMAS F. CLARK.

Superintendent of buildings and grounds.—L. L. OLIVER.

Assistant superintendents of buildings and grounds.—CHARLES C. SINCLAIR, ANDREW F. MICHAELS, JR.

Chief, personnel division.—JACK B. NEWMAN.

Chief, supply division.—ANTHONY W. WILDING.

Chief, photographic laboratory.—F. B. KESTNER.

UNITED STATES NATIONAL MUSEUM

Director.—A. Remington Kellogg.

Exhibits specialist.—J. E. Anglim.

Exhibits workers.—T. G. Baker, R. W. S. Browne, R. O. Hower, W. T. Marinetti, Morris M. Pearson.

Chief, office of correspondence and records.—Helena M. Weiss.

Department of Anthropology:

Frank M. Setzler, head curator; A. J. Andrews, exhibits preparator; W. W. Taylor, Jr., collaborator in anthropology.

Division of Archeology: Waldo R. Wedel, curator; Clifford Evans, Jr., associate curator; George S. Metcalf, museum aide.

Division of Ethnology: H. W. Krieger, curator; J. C. Ewers, C. M. Watkins, associate curators; R. A. Elder, Jr., assistant curator.

Division of Physical Anthropology: T. Dale Stewart, curator; M. T. Newman, associate curator.

Associate in Anthropology: Neil M. Judd.

Department of Zoology:

Waldo L. Schmitt, head curator; W. L. Brown, chief exhibits preparator; C. H. Aschemeier, W. M. Perrygo, E. G. Laybourne, C. S. East, J. D. Biggs, exhibits preparators; W. L. Goodloe, exhibits worker; Mrs. Aime M. Awl, scientific illustrator.

Division of Mammals: D. H. Johnson, acting curator; H. W. Setzer, Charles O. Handley, Jr., associate curators; A. Brazier Howell, collaborator; Gerrit S. Miller, Jr., associate.

Division of Birds: Herbert Friedmann, curator; H. G. Deignan, associate curator; Gorman M. Bond, museum aide; Alexander Wetmore, research associate and custodian of alcoholic and skeleton collections; Arthur C. Bent, collaborator.

Division of Reptiles and Amphibians: Doris M. Cochran, associate curator.

Division of Fishes: Leonard P. Schultz, curator; E. A. Lachner, associate curator; Robert H. Kanazawa, museum aide.

Division of Insects: O. L. Cartwright, acting curator; R. E. Blackwelder, W. D. Field, Grace E. Glance, associate curators; Sophy Parfin, junior entomologist; W. L. Jellison, M. A. Carriker, R. E. Snodgrass, collaborators.

Section of Hymenoptera: W. M. Mann, Robert A. Cushman, assistant custodians.

Section of Diptera: Charles T. Greene, assistant custodian.

Section of Coleoptera: L. L. Buchanan, specialist for Casey collection.

Division of Marine Invertebrates: F. A. Chace, Jr., curator; Frederick M. Bayer, associate curator; Mrs. L. W. Peterson, museum aide; Mrs. Harriet Richardson Searle, Max M. Ellis, J. Percy Moore, collaborators; Mrs. Mildred S. Wilson, collaborator in copepod Crustacea.

Division of Mollusks: Harald A. Rehder, curator; Joseph P. E. Morrison, R. Tucker Abbott, associate curators; W. J. Byas, museum aide; Paul Bartsch, associate.

Section of Helminthological Collections: Benjamin Schwartz, collaborator.

Associates in Zoology: T. S. Palmer, W. B. Marshall, A. G. Böving, C. R. Shoemaker, Austin H. Clark.

Collaborator in Zoology: R. S. Clark.

Collaborator in Biology: D. C. Graham.

DEPARTMENT OF BOTANY (NATIONAL HERBARIUM):

Jason R. Swallen, head curator.

Division of Phanerogams: A. C. Smith, curator; E. C. Leonard, E. H. Walker, Lyman B. Smith, associate curators; Velva E. Rudd, assistant curator; E. P. Killip, research associate.

Division of Ferns: C. V. Morton, curator.

Division of Grasses: Ernest R. Sohns, associate curator; Mrs. Agnes Chase, F. A. McClure, research associates.

Division of Cryptogams: C. V. Morton, acting curator; Paul S. Conger, associate curator; John A. Stevenson, custodian of C. G. Lloyd mycological collections and honorary curator of Fungi.

DEPARTMENT OF GEOLOGY:

W. F. Foshag, head curator; J. H. Benn, museum geologist; Jessie G. Beach, museum aide.

Division of Mineralogy and Petrology: W. F. Foshag, acting curator; E. P. Henderson, G. S. Switzer, associate curators; F. E. Holden, physical science aide; Frank L. Hess, custodian of rare metals and rare earths.

Division of Invertebrate Paleontology and Paleobotany: Gustav A. Cooper, curator; A. R. Loeblich, Jr., David Nicol, associate curators; Robert J. Main, Jr., museum aide; J. Brookes Knight, research associate in paleontology.

Section of Invertebrate Paleontology: J. B. Reeside, Jr., custodian of Mesozoic collection; Preston Cloud, research associate.

Section of Paleobotany: Roland W. Brown, research associate.

Division of Vertebrate Paleontology: C. L. Gazin, curator; D. H. Dunkle, associate curator; F. L. Pearce, exhibits preparator.

Associates in Mineralogy: W. T. Schaller, S. H. Perry, J. P. Marble.

Associate in Paleontology: R. S. Bassler.

DEPARTMENT OF ENGINEERING AND INDUSTRIES:

Frank A. Taylor, head curator.

Division of Engineering: Frank A. Taylor, acting curator; R. P. Multhauf, associate curator.

Section of Civil and Mechanical Engineering: Frank A. Taylor, in charge.

Section of Marine Transportation: Frank A. Taylor, in charge.

Section of Electricity: K. M. Perry, associate curator.

Section of Physical Sciences and Measurement: Frank A. Taylor, in charge.

Section of Land Transportation: S. H. Oliver, associate curator.

Division of Crafts and Industries: W. N. Watkins, curator; Edward C. Kendall, associate curator; E. A. Avery, William E. Bridges, museum aides; F. L. Lewton, research associate.

Section of Textiles: Grace L. Rogers, assistant curator.

Section of Wood Technology: W. N. Watkins, in charge.

Section of Manufactures: Edward C. Kendall, associate curator.

Section of Agricultural Industries: Edward C. Kendall, associate curator.

Division of Medicine and Public Health: George B. Griffenhagen, associate curator; Alvin E. Goins, museum aide.

Division of Graphic Arts: Jacob Kainen, curator; J. Harry Phillips, Jr., museum aide.

Section of Photography: A. J. Wedderburn, Jr., associate curator.

DEPARTMENT OF HISTORY:

Mendel L. Peterson, acting head curator.

Divisions of Military History and Naval History: M. L. Peterson, associate curator; J. R. Sirlouis, assistant curator; Craddock R. Goins, Jr., junior historian.

Division of Civil History: Margaret W. Brown, associate curator; Frank E. Klapthor, museum aide; B. W. Lawless, exhibits worker.

Division of Numismatics: S. M. Mosher, associate curator.

Division of Philately: Franklin R. Bruns, Jr., associate curator.

BUREAU OF AMERICAN ETHNOLOGY

Director.—MATTHEW W. STIRLING.
Associate Director.—FRANK H. H. ROBERTS, JR.
Anthropologists.—H. B. COLLINS, JR., PHILIP DRUCKER.
Collaborators.—FRANCES DENSMORE, JOHN R. SWANTON, A. J. WARING, JR.
Research associate.—JOHN P. HARRINGTON.
Scientific illustrator.—E. G. SCHUMACHER.
RIVER BASIN SURVEYS.—FRANK H. H. ROBERTS, JR., *Director.*

ASTROPHYSICAL OBSERVATORY

Director.—LOYAL B. ALDRICH.
DIVISION OF ASTROPHYSICAL RESEARCH:

Chief.—[Vacancy.]

Instrument makers.—D. G. TALBERT, J. H. HARRISON.

Research associate.—CHARLES G. ABBOT.

Table Mountain, Calif., field station.—ALFRED G. FROILAND, STANLEY L. ALDRICH, physicists; JOHN A. PORA, physical science aide.

Calama, Chile, field station.—FREDERICK A. GREELEY, JAMES E. ZIMMERMAN, physicists.

DIVISION OF RADIATION AND ORGANISMS:

Chief.—R. B. WITHROW.

Plant physiologists.—WILLIAM H. KLEIN, LEONARD PRICE, V. B. ELSTAD, MRS. ALICE P. WITHROW, CHAO C. MOH.

NATIONAL COLLECTION OF FINE ARTS

Director.—THOMAS M. BEGGS.
Curator of ceramics.—P. V. GARDNER.
Chief, Smithsonian Traveling Exhibition Service.—MRS. ANNEMARIE H. POPE.
Exhibits preparator.—ROWLAND LYON.

FREER GALLERY OF ART

Director.—A. G. WENLEY.
Assistant Director.—JOHN A. POPE.
Assistant to the Director.—BURNS A. STUBBS.
Associate in Near Eastern art.—RICHARD ETTINGHAUSEN.
Associate in technical research.—RUTHERFORD J. GETTENS.
Assistant in research.—HAROLD P. STERN.
Research associate.—GRACE DUNHAM GUEST.
Honorary research associate.—MAX LOEHR.
Consultant to the Director.—KATHERINE N. RHOADES.

NATIONAL AIR MUSEUM

Advisory Board:
LEONARD CARMICHAEL, *Chairman.*
[Vacancy], *U. S. Air Force.*
REAR ADM. APOLLO SOUCEK, *U. S. Navy.*
GROVER LOENING.
WILLIAM B. STOUT.
Head curator.—PAUL E. GARBER.
Associate curator.—R. C. STROBELL.
Manager, National Air Museum Facility.—W. M. MALE.
Museum aides.—STANLEY POTTER, WINTHROP S. SHAW.

NATIONAL ZOOLOGICAL PARK

Director.—WILLIAM M. MANN.
Assistant Director.—ERNEST P. WALKER.
Head Animal Keeper.—FRANK O. LOWE.

CANAL ZONE BIOLOGICAL AREA

Resident Manager.—JAMES ZETEK.

INTERNATIONAL EXCHANGE SERVICE

Chief.—D. G. WILLIAMS.

NATIONAL GALLERY OF ART

Trustees:
EARL WARREN, Chief Justice of the United States, *Chairman.*
JOHN FOSTER DULLES, Secretary of State.
GEORGE M. HUMPHREY, Secretary of the Treasury.
LEONARD CARMICHAEL, Secretary of the Smithsonian Institution.
SAMUEL H. KRESS.
FERDINAND LAMMOT BELIN.
DUNCAN PHILLIPS.
CHESTER DALE.
PAUL MELLON.
President.—SAMUEL H. KRESS.
Vice President.—FERDINAND LAMMOT BELIN.
Secretary-Treasurer.—HUNTINGTON CAIRNS.
Director.—DAVID E. FINLEY.
Administrator.—ERNEST R. FEIDLER.
General Counsel.—HUNTINGTON CAIRNS.
Chief Curator.—JOHN WALKER.
Assistant Director.—MACGILL JAMES.

Report of the Secretary of the Smithsonian Institution

LEONARD CARMICHAEL

For the Year Ended June 30, 1954

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: I have the honor to submit a report showing the activities and condition of the Smithsonian Institution and its branches for the fiscal year ended June 30, 1954.

GENERAL STATEMENT

The period covered by this report is the first full year in which I have served as Smithsonian Secretary. Certainly this has been an active and fruitful year at the Institution. An extensive program of renovation and remodeling of our exhibitions has been carried forward.

Modernization Program Under Way

The first wholly new exhibition hall to be completed in many years at the Smithsonian, "Highlights of Latin American Archeology," was opened to the public on April 14, 1954. The hall shows in a modern and graphic way the development of the archeology of Central and South America in the Pre-Columbian period. A number of Smithsonian Regents, representatives of the Council of the 21 republics of the Organization of American States, other ambassadors to the United States from Latin America, as well as many scientists and State Department officials, attended the opening ceremony. The significance of the new hall lies not only in the excellent way it presents the special facts of Pre-Columbian archeology. It also exemplifies the plan of the Smithsonian to carry forward in an orderly program the reconditioning and modernization of exhibitions in the entire Institution. This new hall shows many new departures for us in modern museum techniques, in lighting, and in the use of color. The visitor who enters the hall and moves from case to case through the exhibits cannot fail to leave with a real understanding of Central and South American cultures before the coming of Columbus. The exhibition is thus a true teaching device. No materials have been lost from the previous exhibits of South American pottery or stone

implements, but duplicate or near duplicate articles have been moved from their old cluttered cases in the public exhibition rooms to well-organized study collections.

Excellent progress also was made in preparing a new hall in which the dresses of the First Ladies of the White House can be properly displayed. This is an exhibit that is much appreciated by our many women visitors.

If progress in the modernization program comparable to that made during the present year can be continued for nine years, it will be possible to transform entirely the outmoded, inadequate, and all too often uninstructive features of the Smithsonian exhibitions so that they can all be seen in a modern suitable setting.

Building Plans Gain Momentum

Much of the year has also been devoted to preliminary planning for the new buildings that are so urgently needed to make all our museums here at the Smithsonian comparable to the national museums of other great nations. At the annual meeting of the Board of Regents last year consideration was given to the further development of plans for these buildings. The studies that had been made in recent years were reviewed. At the direction of the Board, and with the help of our staff, we are continuing the work on this important problem.

It becomes increasingly clear that the scientific and scholarly research of the Institution, as well as its museum functions, cannot be adequately served without the erection of not one but three new buildings. One of these must house in a suitable and modern way our unequaled collections in American history and in applied science and technology. Another must properly provide for the National Air Museum. The third proposed required building is a new gallery for the National Collection of Fine Arts.

A few words about plans for each of these buildings may be appropriate here.

This year much progress was made in developing detailed specifications for the new Museum of History and Technology, and an illustrated booklet descriptive of the needs of this building was assembled. The Bureau of the Budget allowed the Institution to request the Congress to authorize planning for this building. Legislation looking to this end was introduced in the Senate by Senator Edward Martin, chairman of the Senate Committee on Public Works. This bill was passed by the Senate. A similar bill was introduced in the House of Representatives by Congressman George A. Dondero, chairman of the House Committee on Public Works. This bill was not brought to the floor. In preparing this legislation and in its consideration by the

Congress favorable comments concerning the need for such a building were given by the Fine Arts Commission, the National Capital Planning Commission, and other interested groups, including the press. It is hoped that in the next session of Congress enabling legislation of this sort may be enacted.

A gift of funds to the Institution from the Aircraft Association and the Air Transport Association made it possible to obtain the services of an architectural firm to make preliminary studies for a suitable building to house the Wright brothers' *Kitty Hawk Flyer*, Lindbergh's *Spirit of St. Louis*, America's first supersonic jet plane, and all the other great planes and aeronautical equipment that make up the Smithsonian's world-famous and unique collection of aircraft and aviation materials. When these plans are complete, it will be necessary to consider various possible ways in which this necessarily large and expensive structure can be financed and built.

Fifteen years ago an architects' competition was held for a design for a building to house the Smithsonian's National Collecton of Fine Arts and also to provide a place for the exhibition of works of art created by living American artists and related displays. It was agreed then and it is still clear that the great National Gallery of Art, which is also a bureau of the Smithsonian Institution, cannot and should not try to perform this function. Similarly, the Smithsonian's Freer Gallery of Art, which was given to the Nation by a citizen for very specific purposes, cannot be used for this broader purpose. It is now by no means sure that the design that won the architectural competition for the new gallery in 1939 will meet all its now recognized needs. It is certain, however, that the country does require and somehow must secure a gallery to perform the functions outlined above. It was just 50 years ago that by a court decree the art collections of the Smithsonian Institution were "designated and established" as this country's national gallery of art, but in all that time there has been no adequate housing either for proper protection or display. The collections have grown in size and importance, as witness the large and valuable Gellatly collection added to it by gift in 1933, and the time has come when the Government must assume full obligation toward this priceless cultural asset of our country. Certainly all of us who are interested in the Institution must do our best to consider ways to achieve this important goal.

Other museum buildings are also needed. A national planetarium has with wisdom over and over again been proposed for location at the Smithsonian. Additional buildings at the Smithsonian's National Zoological Park are also required.

The last great building for our nation's collections to be erected from Federal funds was the Natural History Building. This monumental structure was opened more than 40 years ago. Since that time

two outstanding art buildings have been assigned to the Smithsonian for administration. Both of these were financed by generous gifts made to the United States by public-spirited citizens. Every day tens of thousands of Americans have reason for gratitude for the wisdom and generosity of Andrew W. Mellon for making possible the National Gallery of Art and to Charles Lang Freer for his gift to the country of the gallery which bears his name. Either by Federal appropriations or by further private gifts it is hoped that the United States, which has the world's greatest museum collections, now aggregating more than 35 million cataloged objects, may be housed in an appropriate way. Invaluable lessons in patriotism and science and in artistic appreciation are now learned in our buildings. Last year over 8,100,000 visitors were counted in all our buildings. With modern and adequate structures, possibly twice this number of American citizens could be served and instructed every year.

River Basin Program Curtailed

Details of the operation of the ten bureaus administered by the Smithsonian Institution are given elsewhere in this report. It should be noted here that the funds that have previously been transferred to the Smithsonian from the Department of the Interior in order to make possible the study of the archeology of the river valleys of the West have been sharply restricted. Authorities have estimated that 80 percent of the important archeological remains which allow the study of the early life of the original Americans are in river valleys. Many of the most important of these sites are now being covered by water as new dams are filling up. Emergency help with this program is now being requested from nongovernmental sources. It is sincerely hoped that in some way next year the Federal Government may again make available the relatively small sum that would allow the continuation of this emergency work before it is forever too late.

It may be appropriate to remark here that the appeal of the Smithsonian to outside donors for special funds to assist in this emergency is by no means an isolated case. Much of the work of the Institution today can be accomplished only because of the gifts and grants which are transferred to it from philanthropic individuals, foundations, and other agencies.

Protection of Cultural Property in Wartime

The Secretary of the Smithsonian Institution was appointed by the President of the United States to serve as chairman of a United States delegation to an international congress which met at The Hague this spring to negotiate a treaty for the protection throughout the world

of museums, galleries, and historic monuments and cultural property in general in time of armed conflict. This conference was attended by 48 nations, including the U. S. S. R. A satisfactory treaty was formulated, and I had the honor of signing for the United States. Cynical individuals may express the feeling that in the present era of atomic warfare such a treaty has little value. It does not seem certain, however, that a unanimous expression of regard for cultural and scientific property by all the great powers of the world is without general significance even in the present period of history. Certainly the treaty for the first time regularizes the steps that must be taken to try to protect museums such as those in the Smithsonian group in time of war.

Bio-Sciences Information Exchange

The Smithsonian now operates for a number of other governmental and nongovernmental organizations a Bio-Sciences Information Exchange. This agency, under the direction of Dr. Stella L. Deignan, provides current information in regard to research that is under way in biology, medicine, and related fields. Funds for this operation are provided by special grants made to the Smithsonian Institution.

The staff of the Smithsonian Institution joins me in expressing deep appreciation to the Chancellor and the Regents of the Smithsonian Institution for all they have done during the present year to advance the well-being of the Smithsonian. The needs of the Institution are many. But certainly the year that has passed has been one that has seen solid achievement and important accomplishments in many fields.

THE ESTABLISHMENT

The Smithsonian Institution was created by act of Congress in 1846, in accordance with the terms of the will of James Smithson, of England, who in 1826 bequeathed his property to the United States of America "to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men." In receiving the property and accepting the trust, Congress determined that the Federal Government was without authority to administer the trust directly, and, therefore, constituted an "establishment" whose statutory members are "the President, the Vice President, the Chief Justice, and the heads of the executive departments."

THE BOARD OF REGENTS

The past year brought the death of two valued Regents of the Smithsonian Institution. Fred M. Vinson, Chief Justice of the United

States and Chancellor as well as Regent of the Smithsonian Institution, died on September 8, 1953. Chancellor Vinson had served as the presiding officer of the Board since June 24, 1946. His enthusiastic work for the welfare of the Smithsonian and his willingness to advance its various programs will always be remembered with gratitude by all who are interested in the work of the Institution. The death of Senator Robert A. Taft was also a severe loss to the Institution. Senator Taft became a Regent of the Smithsonian on March 9, 1953, and his untimely death occurred on July 31, 1953. During this short period Senator Taft had naturally not been able to perform many official acts in relation to the Smithsonian, but he had indicated his desire to be of full service to the Institution.

The Board is honored to welcome as a new member the Honorable Owen J. Roberts of Philadelphia. It is my pleasure also to record the appointment to the Board of Regents of Senator H. Alexander Smith, of New Jersey, and the reappointment of Robert V. Fleming and Vannevar Bush.

On the evening of January 14, 1954, an informal dinner meeting of the Board was held in the main hall of the Smithsonian Institution. The chairman of the executive committee, Robert V. Fleming, presided. The holding of this dinner on the evening before the annual meeting of the Board is now a well-established custom at the Smithsonian. At the dinner this year research reports were made by a representative group of Smithsonian scientific and scholarly workers. A special exhibit was also arranged to show the plans of the Institution for the modernization of its exhibit halls.

The regular annual meeting of the Board was held on January 15 in the Regents Room of the Institution. At this meeting the Chief Justice of the United States, Honorable Earl Warren, was unanimously elected as the Chancellor of the Institution. The Secretary presented his published annual report on the activities of the Institution and its bureaus. The financial report was presented by Robert V. Fleming, chairman of the executive and permanent committees of the Board, for the fiscal year ended June 30, 1954. The usual resolution was passed authorizing expenditures of the income of the Institution for the fiscal year ending June 30, 1955.

The roll of Regents at the close of the present fiscal year was as follows: Chief Justice of the United States Earl Warren, Chancellor; Vice President Richard Nixon; members from the Senate: Clinton P. Anderson, Leverett Saltonstall, H. Alexander Smith; members from the House of Representatives: Clarence Cannon, Leroy Johnson, John M. Vorys; citizen members: Vannevar Bush, Arthur H. Compton, Robert V. Fleming, Jerome C. Hunsaker, and Owen Josephus Roberts.

FINANCES

A statement on finances, dealing particularly with Smithsonian private funds, will be found in the report of the executive committee of the Board of Regents, page 169.

APPROPRIATIONS

Funds appropriated to the Institution for the fiscal year ended June 30, 1954, total $3,000,000, obligated as follows:

Management	$56,134
United States National Museum	1,092,723
Bureau of American Ethnology	63,150
Astrophysical Observatory	111,176
National Collection of Fine Arts	43,839
National Air Museum	144,602
International Exchange Service	87,028
Canal Zone Biological Area	7,880
Maintenance and operation of buildings	1,089,131
Other general services	301,332
Unobligated	505
Reserve (Bureau of the Budget)	2,500
Total	3,000,000

Besides these direct appropriations, the Institution received funds by transfer from other Government agencies as follows:

From the District of Columbia for the National Zoological Park	$660,000
From the National Park Service, Department of the Interior, for the River Basin Surveys	71,495

VISITORS

Visitors to the Smithsonian group of buildings during the year 1953–54 reached a record total of 3,658,881, approximately a quarter of a million more than the previous year. April 1954 was the month of largest attendance, with 585,956; May 1954 was second, with 513,626; August 1953 third, with 448,956. Largest attendance for a single day was 55,305 for May 8, 1954. Table 1 gives a summary of the attendance records for the five buildings. These figures, when added to the 3,616,220 estimated visitors at the National Zoological Park and 887,213 at the National Gallery of Art, make a total number of visitors at the Smithsonian Institution of 8,162,314.

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TABLE 1.—*Visitors to certain Smithsonian buildings during the year ended June 30, 1954*

Year and month	Smithsonian Building	Arts and Industries Building	Natural History Building	Aircraft Building	Freer Building	Total
1953						
July	71,413	229,917	82,665	27,941	7,546	419,482
August	86,587	225,650	93,657	34,142	8,920	448,956
September	46,568	112,853	58,077	[1] 12,739	6,451	236,688
October	45,111	137,052	71,132	16,561	5,278	275,134
November	31,605	69,693	50,179	14,863	4,220	170,560
December	22,993	51,818	36,412	11,120	2,494	124,846
1954						
January	24,708	46,903	46,245	9,801	3,060	130,717
February	30,284	78,924	49,823	26,295	3,944	189,270
March	33,024	85,947	55,866	24,792	4,005	203,634
April	104,204	294,030	115,980	62,321	9,421	585,956
May	92,315	249,080	117,082	46,462	8,687	513,626
June	63,266	166,250	84,828	36,947	7,721	360,012
Total	652,078	1,748,117	861,955	324,984	71,747	3,658,881

[1] Building closed 8 days for installation of the *Excalibur III*.

During the year a special record was kept of groups of school children visiting the Institution. The figures are given in table 2:

TABLE 2.—*Groups of school children visiting the Smithsonian, 1953–54*

Year and month	Groups	Children
1953:		
July	109	3,038
August	83	1,923
September	47	1,161
October	351	8,030
November	335	9,544
December	198	5,414
1954:		
January	183	4,042
February	260	7,310
March	518	19,058
April	1,543	62,691
May	2,218	91,441
June	771	26,977
	6,616	240,629

LECTURES

In 1931 the Institution received a bequest from James Arthur, of New York, a part of the income from which was to be used for an annual lecture on some aspect of the study of the sun. The twenty-first Arthur lecture was delivered in the auditorium of the Natural History Building on the evening of May 27, 1954, by Dr. John W.

Evans, superintendent of the Upper Air Research Observatory, Air Force Cambridge Research Center, Sunspot, N. Mex. The subject of Dr. Evans's address was "Solar Influence on the Earth." This lecture will be published in full in the general appendix to the Annual Report of the Board of Regents of the Smithsonian Institution for 1954.

Dr. Henry Thompson Rowell, chairman of the department of classics at Johns Hopkins University, delivered a lecture in the auditorium of the Natural History Building on the evening of January 28, 1954, on the subject "Rome of the Flavians." This lecture was sponsored jointly by the Smithsonian Institution and the Archaeological Institute of America.

Dr. Charles Greeley Abbot, former Secretary of the Smithsonian Institution, on April 1, 1954, lectured on "The Smithsonian Astrophysical Observatory." He related the distinguished history of the Astrophysical Observatory and described the important research this agency has been and is doing, both in Washington and at its field stations in California and Chile, in scientific studies of solar energy and radiation as related to life on the earth.

SUMMARY OF THE YEAR'S ACTIVITIES OF THE INSTITUTION

National Museum.—The working collections of the Smithsonian Institution are an essential tool to scientists who come to us from all over the country. On an average day at least 100 scientists, not on the Smithsonian staff, are at work in our buildings and laboratories. To keep these working collections, which are in one sense the "bureau of standards" in our fields, in a growing and as complete as possible a form is most important. This year these unique and world-famous collections were increased by approximately 632,000 specimens during the year, bringing the total catalog entries to 35,302,807. Some of the year's outstanding accessions included: In anthropology, over 8,700 objects from an archeological site in Kansas representing the earliest date ever assigned to a pottery-bearing site in the Central Plains, 800 archeological specimens from Korea, and a collection of ethnographical materials from southern Colombia; in zoology, 1,500 small mammals from Korea, 625 mammals, 1,800 birds, and 100,000 mosquitoes from Thailand, nearly 5,600 marine invertebrates from the Caroline Islands, and 32,000 Cuban shells; in botany, about 24,000 plant specimens from the Fiji Islands and a transfer of over 65,000 miscellaneous plants from the herbarium of the National Arboretum; in geology, 2,000 selected negatives of photomicrographs of meteoric iron, the finest known crystal of the rare mineral genthelvite, many fine fossil invertebrates, and 600 rare Paleocene and Eocene mammals; in engineering and industries, an early wool-carding machine and important additions to the antibiotic exhibit; and in history, a one-

horse open sleigh of the Colonial period and the inaugural gown of Mrs. Dwight D. Eisenhower.

Members of the staff conducted fieldwork in Thailand, Venezuela, Panama, Caroline Islands, Fiji, Mexico, and many parts of the United States. Several studied collections in European museums.

Good progress was made in the Museum's program of exhibit modernization, and one new hall, "Highlights of Latin American Archeology," was opened to the public.

Bureau of American Ethnology.—The Bureau staff continued their ethnological research and publication: Dr. Stirling his studies of Panamanian archeology, Dr. Collins his activities in the Arctic, Dr. Harrington his work on certain California Indians, and Dr. Drucker his investigations relating to the Indians of southern Mexico and of the northwest coast of North America. Dr. Roberts continued as Director of the River Basin Surveys.

Astrophysical Observatory.—Work on two major publication projects was completed during the year—Volume 7 of the Annals of the Astrophysical Observatory and the ninth revised edition of the Smithsonian Physical Tables. Contract work with the Office of the Quartermaster General, in progress for about 8 years, was terminated on September 30. Solar-radiation studies were continued at the Observatory's two field stations—Table Mountain in California and Mount Montezuma in Chile. In the division of radiation and organisms important studies were made on the factors involved in photomorphogenesis, the process by which light exerts its formative effect on higher green plants.

National Collection of Fine Arts.—The Smithsonian Art Commission met on December 1, 1953, and accepted 4 oil paintings, 1 watercolor, 4 miniatures, 3 bronzes, and 7 ceramic pieces. An addition of $5,000 was made to the Barney fund. The Gallery held 12 special exhibitions during the year. The Smithsonian Traveling Exhibition Service circulated 51 exhibitions, 46 in the United States and Canada and 5 abroad.

Freer Gallery of Art.—Purchases for the collections of the Freer Gallery included Chinese bronzes, jade, painting, pottery, and sculpture; Japanese painting; Persian metalwork, painting, and pottery; Syrian metalwork; Arabic painting, Indian painting, and Egyptian painting; and Mesopotamian and Turkish pottery. A series of illustrated lectures by distinguished art scholars, on subjects germane to the Gallery's activities, was given in the auditorium.

National Air Museum.—Progress was made in transporting the stored collections of the Museum from Park Ridge, Ill., to Suitland, Md. The Museum participated in the celebration of the Golden Anniversary of the Wright brothers' first flight, and a special exhibit in connection therewith was installed. For its aeronautical collections

the Museum received during the year 360 specimens from 48 sources, comprising 55 separate accessions—20 percent more than the highest previous year. Full-sized aircraft received included the Douglas XB–43, America's first jet-propelled bomber; the Boeing 247–D transport plane *Adaptable Annie*, flown in the 1934 MacRobertson Race; a German Pfalz D–12 fighter airplane of World War I; and a German rotary-wing autogiro kite, FA–330, used with submarines in World War II.

National Zoological Park.—The Zoo received 899 accessions during the year, aggregating 2,250 individual animals, and 2,011 were removed by death, exchange, et cetera. The net count of animals at the close of the year was 2,980. Noteworthy among the accessions were an example of the rare reptile tuatara from New Zealand, two Philippine macaques, three shipments of mammals from Borneo and the Malay Peninsula, two young Malayan sun bears, and two Korean bear cubs. In all, 194 creatures were born or hatched at the Zoo during the year—74 mammals, 91 birds, and 29 reptiles. Visitors totaled approximately 3,616,000.

Canal Zone Biological Area.—During the year approximately 500 visitors came to Barro Colorado Island; 22 of these were scientists who used the facilities of the station to further their various researches, particularly in biology, geology, and photography.

International Exchange Service.—As the official United States agency for the interchange of governmental, scientific, and literary publications between this country and other nations, the International Exchange Service during the year handled 1,020,509 packages of such publications, weighing 797,320 pounds—slightly less than the previous year. Consignments were made to all countries except China, North Korea, and Rumania.

National Gallery of Art.—The Gallery received 1,010 accessions during the year, by gift, loan, or deposit. Works of art accepted included, among others, paintings by Eakins, George Fuller, Melchers, Boucher, George Luks, Morse, Stuart, Blakelock, and Corot; two bronzes by Daumier; a porphyry vase; and about 300 prints and drawings. Eight special exhibitions were held. Traveling exhibitions of prints from the Rosenwald Collection were circulated to 17 other galleries and museums. Exhibitions from the "Index of American Design" were given 69 bookings in 23 States and the District of Columbia and also in Western Germany and Palestine. Nearly 42,000 persons attended the Gallery's special tours and the "Picture of the Week" talks, and 10,600 attended the 38 Sunday afternoon lectures in the auditorium. The Sunday evening concerts in the west garden court were continued.

Library.—The Smithsonian library received a total of 69,484 publications during the year. Over 500 new exchanges for the library were arranged. Notable among the year's gifts were several hundred zoological publications from the National Museum's former curator of mammals, Gerrit S. Miller, Jr. At the close of the year the holdings of the Smithsonian library and all its branches aggregated 945,562 volumes, including 584,590 in the Smithsonian Deposit in the Library of Congress but excluding incomplete volumes of serials and many thousands of separates and reprints from serials.

Publications.—An organizational change made during the year combined the Editorial Division and the Publications Division into the Editorial and Publications Division.

Fifty-nine publications were issued under the Smithsonian imprint during the year (see Report on Publications, p. 163, for full list). Outstanding among these were: The 9th revised edition of the Smithsonian Physical Tables, compiled by William E. Forsythe; "Insect Metamorphosis," by R. E. Snodgrass; "The Reproduction of Cockroaches," by Louis M. Roth and Edwin R. Willis; "Songs and Stories of the Ch'uan Miao," by David C. Graham; "Fishes of the Marshall and Marianas Islands," by Leonard P. Schultz et al.; "Index to Schoolcraft's 'Indian Tribes of the United States'," compiled by Frances S. Nichols; and "The Iroquois Eagle Dance, an Offshoot of the Calumet Dance," by William N. Fenton and Gertrude Prokosch Kurath. In all, 468,600 pieces of printed matter were distributed during the year—141,953 copies of the publications and 326,647 miscellaneous items.

Report on the United States National Museum

SIR: I have the honor to submit the following report on the condition and operations of the United States National Museum for the fiscal year ended June 30, 1954:

COLLECTIONS

During the year 632,243 specimens were added to the national collections and distributed among the six departments as follows: Anthropology, 22,816; zoology, 307,361; botany, 137,609; geology, 54,399; engineering and industries, 1,947; and history, 108,111. This increase is smaller than last year, when the unusual increase resulted from the accession of a large number of small fossils. This year's total is a more normal annual accretion. Most of the accessions were received as gifts from individuals or as transfers from Government departments and agencies. The Annual Report of the Museum, published as a separate document, contains a detailed list of the year's accessions, of which the more important are summarized below. Catalog entries in all departments now total 35,302,807.

Anthropology.—From an archeological site in Phillips County, Kans., a collection of 8,751 objects representing a Woodland-horizon ossuary was transferred by the River Basin Surveys, Bureau of American Ethnology. The large charred wooden samples from this burial site yielded a radiocarbon date of 1343 (±240) years before the present. This is the earliest date ever assigned to a pottery-bearing site in the Central Plains. Over 800 important specimens from archeological sites in Korea were presented by Maj. Howard A. MacCord. By exchange with the American Museum of Natural History in New York, the division of archeology received an important series of diagnostic specimens dated around 2500 B. C. from the Huaca Prieta site along the north coast of Peru.

An interesting gift from Mrs. Eva Jemison Mitchell to the division of ethnology is a charm necklace worn by the Piegan Indian Stabs by Mistake while engaged in horse stealing from neighboring tribes. Attached to the necklace is a pouch of pungent prairie clover, regarded by the Piegans as a potent talisman for obtaining horses. An ear pendant of green jade worn by a Maori chief and rare in museum collections was donated by Comdr. P. J. Cox, Jr. By transfer from the Army Medical Service Graduate School Expedition, through Dr.

David H. Johnson, the division acquired a number of mammal traps fashioned of bamboo by the Dusan natives of North Borneo. Also transferred from the Bureau of American Ethnology was a collection of ethnographical materials, consisting of textiles, weaving paraphernalia, basketry, necklaces, and musical instruments, used by the sub-Andean Indians of southern Colombia.

For the first time in 50 years the division of physical anthropology received a skull with an anomaly not represented heretofore in its collection of 18,000 human skulls. This irregularity consists of an extra suture dividing one of the parietal bones into two nearly equal parts. This skull was found on the surface of the ground near Cleveland, Ohio, and was received for identification from the Federal Bureau of Investigation.

Zoology.—Outstanding among the zoological accessions received were 1,500 small mammals collected in Korea by units of the Army Medical Services in connection with hemorrhagic-fever surveys; 300 mammals obtained in North Borneo jointly by the U. S. Army Medical Research Unit and the British Colonial Office Medical Research Unit; and several lots of mammals from Formosa obtained by Dr. Donald J. Pletsch and medical units of the U. S. Navy. Other noteworthy accessions recorded were 625 mammals from Thailand collected by Robert E. Elbel, a fine series of New England mammals presented by Dr. Harold B. Hitchcock, a collection of southwestern mammals presented by the School of Tropical and Preventive Medicine, Loma Linda, Calif., and 186 specimens from the British Museum (Natural History), adding to the collections several new African and Asiatic species.

From areas in Thailand an important collection of 1,802 skins of birds and other ornithological material was obtained by H. G. Deignan. A valuable gift from Mrs. Charles E. Ramsden of 1,773 skins, 75 skeletons, and 59 sets of eggs of birds from eastern Cuba was added to the collections. A gift of 107 bird skins from Donald W. Lamm made a notable addition to earlier donations collected in Mozambique. Dr. A. Wetmore contributed more than 1,200 bird skins and skeletons, and 3 sets of bird eggs collected in Panama.

A noteworthy representation of Egyptian reptilian and amphibian material comprising 1,042 specimens collected by Dr. Robert E. Kuntz of the U. S. Naval Medical Research Unit No. 3 was transferred to the Museum. A valuable gift of 126 Brazilian frogs donated by Dr. C. F. Walker was added to the collections. An exchange with the University of Illinois through Dr. Hobart M. Smith yielded 56 specimens, including paratypes of 50 species of reptiles and amphibians.

About 200 fishes collected in the Gulf of Mexico during the cruise of the *Oregon* were transferred to the collections by the U. S. Fish and Wildlife Service through Stewart Springer. An entire collec-

tion consisting of 3,694 foreign fishes was received from the State University of Iowa through Dr. Walter Thietje. These specimens were collected largely in the course of the several university expeditions to various parts of the world by the late Prof. C. C. Nutting, long a collaborator of the Smithsonian Institution. Some 1,155 fishes from the Guadalupe River, Tex., were presented by Robert Kuehne of the State Fish Hatchery at San Marcos. Dr. Giles W. Mead of Stanford University presented 137 fish specimens, including 4 holotypes and 2 paratypes. As exchanges there were added to the collections 22 parrotfishes from the Chicago Natural History Museum through Loren P. Woods; 14 fresh-water fishes including 2 paratypes from Dr. Frank B. Cross, University of Kansas; and 2 paratypes of the North American catfish from the National Museum, Rio de Janeiro, Brazil, through Dr. Paulo de Miranda Ribeiro.

More than 100,000 mosquitoes collected in Thailand by the donors, Mrs. Ernestine Thurman and her late husband, Lt. Comdr. Deed Thurman, formed an extremely important accession. Received from Dr. Annette Braun was a unique and valuable gift of 440 specimens of the work or "mines" of identified leaf-mining insects mounted in 22 books. Dr. Frank Morton Jones presented 3,758 beautifully prepared specimens of skippers and Microlepidoptera. A valuable series of 1,752 elaterid beetles selected from the J. A. Hyslop collection was presented to the museum by Helen Sollers.

By transfer from the Pacific Science Board, National Research Council, the Museum acquired an outstanding collection of approximately 5,760 specimens of miscellaneous marine invertebrates from Ifaluk Atoll, Caroline Islands, through F. M. Bayer. Also transferred were 65 crustaceans from the Joint U. S. Army-British Colonial Office Scrub Typhus Expedition, obtained in North Borneo through Capt. Bryce C. Walton. Among the more important gifts were 1,584 invertebrates from Arno Atoll, Marshall Islands, and Yap Island, Caroline Islands, received from Dr. Robert W. Hiatt; 35 bathypelagic nemerteans, including 16 type specimens, from the eastern Pacific presented by Dr. Wesley R. Coe, Scripps Institution of Oceanography; 271 crustaceans from Saipan, Marianas Islands, donated by Dr. A. H. Banner, University of Hawaii; 534 crustaceans, including the holotype, allotype, and morphotype of a crayfish from Virginia, received from Dr. Horton H. Hobbs, Jr., University of Virginia.

The Museum's collection of Cuban shells was greatly enhanced this year by two significant donations. Mrs. Charles E. Ramsden of Cuba presented to the collections about 23,200 specimens acquired by her late husband and comprising one of the largest accessions of Cuban land shells. Likewise Señora Blanca de la Torre de Rosales of Cuba donated a valuable collection of some 8,930 land shells, including 81

cotypes, made by her husband, the late Dr. Carlos de la Torre. Other important gifts included 170 specimens from Portuguese East Africa, received from Frederico Marques Borges; about 6,000 land and freshwater mollusks of Texas from C. D. Orchard, and 111 Mexican land mollusks including 69 paratypes of eight new species described by H. A. Pilsbry, from the Academy of Natural Sciences of Philadelphia.

Botany.—Under a grant from the National Science Foundation, Dr. A. C. Smith obtained 24,161 botanical specimens in the Fiji Islands. Dr. Ernest R. Sohns collected 1,143 plants in Tlaxcala and Michoacán, Mexico. About 2,780 specimens were collected in Brazil by Dr. Lyman B. Smith in connection with his studies of bromeliads in relation to malaria under the auspices of the Rockefeller Foundation, the Serviço Nacional de Malária, and other Brazilian institutions. Dr. E. H. Walker collected 126 plants from the Ryukyu Islands. E. P. Killip collected 1,400 specimens from the Isle of Pines, Cuba, and 1,090 from Big Pine Key, Fla.

By transfer from the herbarium of the National Arboretum, U. S. Department of Agriculture, an interesting lot of 65,327 miscellaneous plants was received. An important collection of 893 plants of Iran, collected by K. H. Rechinger, and 187 ferns of Malaya were purchased by the herbarium.

Gifts included 1,056 plants of Tonga from Dr. T. H. Yuncker of De Pauw University; 433 plants of Mexico from Prof. Eizi Matuda, México, D. F.; and 1,048 Virginia and West Virginia plants from H. A. Allard.

Among the numerous collections received in exchange were 2,505 plants from the Universitets Botaniske Museum, Copenhagen; 870 plants of Haiti from the Naturhistoriska Riksmuseet, Stockholm; 688 plants of the Dominican Republic from the Arnold Arboretum; 543 plants of Mexico from the University of Michigan; 391 plants of Australia from Cornell University; and 350 plants of Russia from the V. L. Komarov Botanical Institute, Academy of Sciences of the U. S. S. R., Leningrad.

Geology.—Many fine geological specimens were received as gifts, including the finest known crystal of the rare mineral genthelvite from J. W. Adams; a rich mass of pitchblende from the famous Mi Vida mine, donated by the owner, Charles Steen, and an excellent exhibition specimen of prehnite from a new Virginia locality presented by Mr. and Mrs. John D. Atkins.

To the Roebling collection were added two unusual groups of large aquamarine crystals, an aquamarine crystal with brilliant natural facets, and a large crystal of pale yellowish-green spodumene, the variety triphane, all from the state of Minas Gerais, Brazil; a pendant of white opal with rich fire from South Australia, a black opal from New South Wales, a synthetic emerald crystal made in the laboratories

of Carroll Chatham, San Francisco, and a 5½-carat cut brown spene from Baja California.

A suite of well-crystallized minerals from the lead-zinc mines of Trepca, Yugoslavia, a group of brown barite crystals from Elk Creek, S. Dak., and a thorianite crystal, about an inch cube, were added to the Canfield collection. Through the Chamberlain bequest additions included a 5-carat brilliant-cut yellow sphene from Baja California. and a 45½-carat morganite of unusual apricot color from Brazil.

A particularly important gift of Dr. Stuart H. Perry to the meteorite collection was his group of 2,000 carefully prepared and selected negatives of photomicrographs of meteoric iron. By exchange the Museum received from Tohoku University, through Prof. Kenzo Yagi, a representative set of rocks from the new Japanese volcano Syowa Sinzan, Hokkaido. Other important additions to the petrological collections were a series of rocks illustrating the petrology of the Hakone Mountains, Japan, as described by Prof. Hisashi Kuno, and of the Highwood Mountains, Mont., as described by Prof. Esper S. Larsen, Jr., Harvard University.

Through funds provided by the Walcott bequest, important invertebrate fossils were acquired by the Museum, including 500 Lower Cretaceous mollusks by Dr. David Nicol; 500 Paleozoic invertebrates collected by Dr. G. A. Cooper, Dr. Arthur Boucot of the U. S. Geological Survey, and Roger Batten of Columbia University; and 7,500 Devonian fossils obtained by Dr. Cooper in Michigan, Ontario, and New York. Additions to the Springer collection included 369 echinoderms from the Pennsylvanian Francis shale of Oklahoma, and 15 rare echinoderms from Devonian rocks of Ontario, Canada.

Gifts included 150 specimens of Triassic fossils from Italy received from Dr. Franco Rasetti; 400 Triassic fossils from Nevada from Dr. J. Lee Adams; 500 Lower Cretaceous mollusks from Texas from Carl R. Chelf; 150 late Miocene mollusks from Washington from S. E. Crumb; and 300 Devonian fossils from New York from Max J. Kopf.

Transfers from other Government agencies included the holotype of the trilobite *Colpocoryphe exsul* Whittington, and the rare trilobite *Hoekaspis* from Bolivia, as well as collections of Eocene radiolaria from Saipan, and of Cretaceous pelecypods, from the U. S. Geological Survey, and a lot of brachiopods from the U. S. Fish and Wildlife Service.

An outstanding collection of over 600 specimens of rare Paleocene and Eocene mammals was obtained by Dr. C. L. Gazin and Franklin L. Pearce in Wyoming under the income of the Walcott bequest. By transfer from the U. S. Geological Survey, through Dr. J. B. Reeside, Jr., the Museum obtained a collection of undistorted fossil fish from the Cretaceous Mowry shale in Wyoming. An important exchange gave the Museum a series of 22 specimens and casts of primitive jaw-

less fish from the Upper Silurian of Norway and Spitsbergen, obtained from the National Museum of Norway. The Ohio Geological Survey, through John H. Melvin, presented to the collections the skull and partial skeleton of a rare embolomerous amphibian from the Pennsylvanian rocks of Ohio. An important purchase through the Walcott bequest included the type specimen of the titanothere from the Eocene Lisbon formation of Mississippi and the skull and jaws of the archeocete whale *Zygorhiza kochii* from the Upper Eocene Jackson formation of Mississippi. These were deposited on loan to the Museum for study several years ago and are significant in that the titanothere furnishes the only direct means of an age correlation between the marine Gulf coast Eocene and the continental Eocene deposits of the Rocky Mountain region. This archeocete skull has furnished the first conclusive evidence of the replacement sequence of deciduous teeth by the permanent series in the order of whales.

Engineering and Industries.—An early automobile speedometer of his design was presented by J. W. Jones, inventor. A schematic model of a gas-turbine, electric-generating plant was donated by the Allis-Chalmers Manufacturing Co. Dr. Walter Cane presented a well-preserved example of the Mignon typewriter. Ralph E. Cropley continued to add to the collection of scrapbook data on watercraft history.

A wool-carding machine constructed from memory in 1793 by John and Arthur Scholfield, English mechanicians, was presented by Davis & Furber Machine Co. Daniel Thompson presented scale models of a water-power grist mill, an ox-power cane mill, and a windmill-driven water lift for a salt works, all operative models of installations formerly in use in Puerto Rico.

Important additions to the wood collections included a group of 279 woods of Fiji collected by Dr. A. C. Smith, 124 woods of Japan, Thailand, Australia, and the Hong Kong market presented by Col. Harold B. Donaldson, and 72 woods of Yucatan, the Marshall Islands, and other regions, transferred by the U. S. Forest Products Laboratory of the Department of Agriculture.

The Museum acquired by purchase through the Dahlgreen fund a series of 17 chiaroscuro woodcuts by John Baptist Jackson, representing the first attempt to reproduce paintings in the block print medium. Thirteen woodcuts, dealing with views of Jerusalem and environs, native types, and subjects from the Old Testament by contemporary Israeli artists, were presented by local donors.

Sir Alexander Fleming, the discoverer of penicillin, presented a specimen of the mold *Penicillium notatum*, and the Sir William Dunn School of Pathology at the University of Oxford, through Dr. N. G. Hestley, donated two of the original porcelain culture vessels from which was prepared the first crystalline penicillin used in clinical

studies. Lederle Laboratories contributed through F. L. Murphy a test tube of some of the original soil from which aureomycin was isolated, and five petri dishes prepared by Dr. Duggar, the discoverer of aureomycin. The Sanborn Co. presented through James L. Jenks, Jr., an electrocardiograph used for taking the first electrocardiogram of a white (beluga) whale, and Dr. Paul Dudley White added the harpoon electrode used in these studies on the whale.

History.—An interesting accession, a gift of Walter Voigt, was a one-horse open sleigh of the Colonial period with the date "1769" carved in the center back panel under a painted pine-tree decoration. Tradition associates the sleigh with Gen. George Washington and his New Jersey campaign of the Revolutionary War. As a gift to the national collection of dresses of the First Ladies of the White House, Mrs. Dwight D. Eisenhower presented her pink-silk inaugural-ball gown. Mrs. Eisenhower also presented her wedding dress of ecru lace to the collection of American period costumes. By donation from Miss Margaret Bream four early American hats and bonnets in a band box of the early nineteenth century were added to the collection of period costumes. Mrs. Elmer R. Shepherd gave to this collection two early nineteenth-century Quaker bonnets and three gauze undercaps. Specimens of furniture and room accessories for use in the series of period rooms of the White House were given by Awbrey N. Shaw and Mrs. W. Murray Crane.

A large collection of German insignia of the period of World War II was presented by William A. Hambley, Jr. A valuable and rare powder horn of 1762 was received from Mrs. Stella Crooks and Miss Ethel Crooks.

An outstanding accession in the division of numismatics was an Indian peace medal of Andrew Johnson dated 1865, presented by Miss Lucia K. Williams.

A total of 2,341 stamps was received as a transfer from the Post Office Department. Of considerable importance were the transfers from the Internal Revenue Service of 57,955 revenue stamps, die proofs, and plate proofs. Gifts of major importance were made by John R. Boker, Jr., Ralph A. Schoenfeld, Ernst Lowenstein, Philip Ward, Jr., and Arthur F. Black.

EXPLORATION, FIELDWORK, AND RELATED TRAVEL

During September and later in the year 1953, Dr. T. Dale Stewart, curator, and Dr. Marshall T. Newman, associate curator, division of physical anthropology, excavated a number of skeletons from a prehistoric Indian ossuary on the farm of Bernward Juhle on Nanjemoy Creek, near Ironsides, Charles County, Md.

In response to a request made by United States Naval Medical

Research Unit No. 3 for a report on the mammals of the Anglo-Egyptian Sudan collected by the staff of that unit, Dr. Henry W. Setzer, associate curator, division of mammals, devoted six weeks to a study of pertinent types and other significant specimens at the British Museum (Natural History) in London.

On September 1, 1953, Herbert G. Deignan, associate curator, division of birds, returned to Washington after completing ornithological field studies in Thailand which were made possible by grants from the John Simon Guggenheim Memorial Foundation and special research funds of the Smithsonian Institution.

Dr. Waldo L. Schmitt, head curator, department of zoology, left for Europe on April 1, 1954, and on arrival at Naples he was introduced to the staff and granted permission by Dr. Reinhard Dohrn, director, to examine the collections of the Stazione Zoologica di Napoli. The director of the Museo Civico di Storia Naturale "G. Doria" in Genoa, Dr. F. Capra, made available the study and exhibit series of crustaceans. At the Instituto di Zoologia, Universita di Torino, by courtesy of Dr. L. Pardi, director, Dr. Schmitt devoted two weeks to the study of *Aegla* and porcellanid collections. After visiting the Musée Océanographique de Monaco, he made a return visit to Naples to obtain a number of brachiopods which had been preserved for anatomical studies by Dr. G. A. Cooper of our Museum staff. While visiting the Musée d'Histoire Naturelle, Geneva, Dr. Schmitt met the new director, Dr. Emil Dottreus, and identified the specimens of *Aegla* in that institution. In Zurich, Dr. Bernard Peyer showed him the well-displayed synoptic collections of the Zoologische Sammlung of the university. Dr. Schmitt then proceeded to Leiden where he was invited by Dr. H. Boschma, director of Rijksmuseum van Natuurlijke Historie, and Dr. Lipke Holthuis to see their collections, which include the type specimens described by de Haan in the Crustacea section of von Siebold's Fauna Japonica and the *Snellius* South Pacific collections. At Utrecht he met Dr. Wagenaar P. Hummelinck of the Zoologisch Museum, Rijks Universiteit, and at Amsterdam was conducted by Mr. T. van der Feen through the Zoologische Museum where, among other important materials, are housed the famous *Siboga* collections. He devoted a week in London to the study of the *Aegla* specimens in the British Museum (Natural History) and another week in Paris examining the carcinological collections of the Muséum National d'Histoire Naturelle. Through the courtesy of the director, Dr. G. Trégouboff, Station Zoologique, Université de Paris, at Villefranche-sur-Mer, he was enabled to inspect the exhibits of local marine flora and fauna. Dr. Schmitt returned to Washington on June 22, 1954.

During January and the early part of February Dr. Alexander

Wetmore, research associate, was the guest of Mr. and Mrs. William H. Phelps, Jr., of Caracas, Venezuela, on an expedition in the Territory of Amazonas, southern Venezuela. The party, which included the geologists Dr. Guillermo Zuloaga, of the Creole Petroleum Co., and Dr. C. D. Reynolds, of the Orinoco Mining Co., and Dr. James H. Kempton, Agricultural Attaché at the American Embassy, left Caracas by plane on the morning of January 2 and flew to Esmeralda on the Upper Orinoco. Landing was made on the savanna, and transferring to two launches the party proceeded to the head of the Caño Casiquiare. That stream, taking about one-third of the water from the Orinoco at this point, flows southward, augmented by several major tributaries, to join the Río Guainía and to form the Río Negro, one of the principal affluents of the Amazon, thus connecting the two great river systems of northern South America. On January 5 the party entered the Río Pacimoni from the Casiquiare and 3 days later came into a branch of this stream known as the Río Yatúa. Presently the forest closed in as the stream narrowed, and it was necessary to transfer to canoes and so to continue through channels that wound through areas where the stream banks were flooded.

A party of botanists under Dr. Bassett Maguire of the New York Botanical Garden had preceded, but in spite of this much time was lost in cutting through fallen trees and in locating the proper channels. A base camp at the head of navigation was reached on January 15, and Wetmore and Kempton remained here for work in the lowland forest, while the rest of the party continued with porters, to join the botanists on Cerro de la Neblina, a 7,000-foot mountain hitherto unknown, near the Brazilian frontier. On January 25, the mountain party having returned, the expedition moved downriver, continued south to San Carlos del Río Negro, and from there back up the Río Guainía to Maroa and Victorino on the Colombian frontier. On February 6 they crossed the 18-kilometer foot trail from Pimichín on the Amazon drainage to Yavita on the Río Temi, which flows into the Atabapo, a tributary of the Orinoco. At Yavita a launch was waiting, and the downstream journey began, ending finally at Puerto Ayacucho, capital of Amazonas. On February 11 the group again reached Caracas, returning by air. Dr. Wetmore had opportunity through the journey to study the northern edge of the great Amazonian forest, and to make collections of birds, not only at the base camp, but also in Colombian territory along the river boundaries.

During the latter half of February and through March, Dr. Wetmore, accompanied by Mrs. Wetmore, continued work on the birdlife of Panama. Attention this season centered on the mountainous areas of western Chiriquí, where through the kindness of Don Pablo Brackney, of Panama City, an excellent base was available at Palo Santo, west of the village of El Volcán. Armageddon Hartmann was em-

ployed to assist in making the collections. Though clearings were extensive, much forest still remained and birds were abundant. The work centered mainly at intermediate elevations between 4,000 and 6,000 feet in the subtropical zone. Many areas could be reached over rough mountain roads and trails by jeep so that the collections obtained covered an extensive terrain. The work included a week at Santa Clara, about 15 miles from the Costa Rican border, where the party had accommodations at the farm of Alois Hartmann, long a resident of Chiriquí. The series of specimens and the notes obtained have added measurably to knowledge of the birdlife of the Republic, and it is hoped to continue the study for another season at higher elevations on the Volcán Barú. In February Dr. Wetmore spent two days on Barro Colorado Island, and at the close of the work the first week in April he made observations at several points adjacent to the Canal Zone.

From May 29 to June 12 Dr. Wetmore represented the Smithsonian Institution and the United States National Museum at the Eleventh International Ornithological Congress held in Basel, Switzerland. Following the meetings he was engaged briefly in studies of the scientific collections of birds in the Naturhistorische Museum in Vienna, and for a period of 5 weeks in the British Museum (Natural History) in London.

Dr. Leonard P. Schultz, curator, division of fishes, was awarded a grant by the National Science Foundation to attend the Eighth Pacific Science Congress in Quezon City, Philippine Islands. Enroute he visited the Zoological Institute, the National Museum of Science, the Institute for Natural Resources, and the Tokaiku Suisan Kenkyiyo (Fisheries Experimental Station) in Tokyo. Following the conclusion of the sessions of this congress on November 28, 1953, Dr. Schultz visited the Indian Museum, Zoological Survey of India at Calcutta, the University of Istanbul and the Hydrobiological Institute at Istanbul, the Laboratorio Centrale di Idrobiologia at Rome, the Muséum National d'Histoire Naturelle and the Laboratory of Colonial Fishes at Paris, and the British Museum (Natural History) at London. He returned to Washington on December 14, 1953.

Frederick M. Bayer, associate curator, division of marine invertebrates, left Washington on September 1, 1953, to join the Fourth Pacific Atoll Survey Team sponsored by the Pacific Science Board of the National Research Council and to participate in a general ecological survey of Ifaluk Atoll in the Caroline Islands. In addition to obtaining extensive collections of marine invertebrates, which are indispensable to a thorough analysis of the biological zonation patterns and the determination of zoogeographical relationships, Mr. Bayer made observations on biological associations at all levels from commensalism to parasitism and studied the role played by alcyo-

narian corals in reef formation for comparison with corresponding conditions elsewhere. Following completion of the survey work on this atoll on November 13, 1953, Mr. Bayer proceeded to Tokyo, Japan, where the Octocorallia collections of Tokyo Imperial University were made available to him through the kindness of Profs. K. Takewaki and T. Fujii of the Zoological Institute Science Faculty. During the week following December 8, Mr. Bayer, through the courtesy of Prof. Huzio Utinomi, was permitted to examine the collections of the Seto Marine Biological Laboratory, Kyoto Imperial University at Shirahama in Wakayama Prefecture. Subsequently at the invitation of the director, Prof. Ichiro Tomiyama, he made three short trips to Misaki Biological Station at Aburatsubo near Misaki on the shores of Sagami Bay. Through Professor Tomiyama's office as investigator on the staff of the Imperial Household, Mr. Bayer was invited to examine the collections of His Imperial Majesty the Emperor of Japan, and while there was extended the honor of an informal scientific interview with His Imperial Majesty. He returned to Washington on January 11, 1954.

Dr. A. C. Smith, curator, division of phanerogams, commenced field studies at Suva, Fiji, under a National Science Foundation research grant on March 29, 1953, and subsequently continued his studies on Viti Levu, Ovalau, Ngau, and Taveuni. Historic type localities were visited, but most areas explored had not been previously botanized. Dr. Smith departed from Suva on January 7, 1954, and returned to Washington January 30.

Dr. E. H. Walker, associate curator, division of phanerogams, attended the Eighth Pacific Science Congress in Quezon City as a delegate for SIRI (Scientific Investigation of the Ryukyu Islands), program of the Pacific Science Board of the National Research Council and the United States Army, and made collections of herbarium materials on Luzon Island in the Philippines, and in Hawaii, Johnston Island, Guam, and Okinawa enroute.

Dr. Ernest R. Sohns, associate curator, division of grasses, was engaged in field work for four weeks in the fall of 1953 in the states of Tlaxcala and Michoacán, Mexico.

C. V. Morton, curator, division of ferns, under a fellowship grant from the John Simon Guggenheim Memorial Foundation, devoted the last three months of the fiscal year to a study of ferns in European herbaria. In August and September 1953 he participated in the field trips of the American Fern Society in New York, Quebec, and Michigan.

Fieldwork by five parties engaged in search for invertebrate and vertebrate fossils was financed by the income from the Walcott bequest. Dr. A. R. Loeblich, Jr., in collaboration with Dr. Helen Tappan

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Loeblich, was engaged for nine months in the study of the types of Foraminifera in European institutions for the Treatise on Invertebrate Paleontology and collected topotype foraminiferal material in England, France, Italy, Spain, Belgium, Netherlands, Germany, and Austria. As a result of this trip the national collections have acquired the largest representation of European Foraminifera in any institution.

Dr. G. A. Cooper, curator, and William T. Allen, museum aide, division of invertebrate paleontology and paleobotany, left Washington in July 1953 for western Texas to carry on geological field work in the Glass Mountains and collect Permian silicified fossils in the Guadalupe Mountains. Subsequently, they obtained a large collection of Permian invertebrate fossils in the vicinity of Carlsbad, N. Mex. Enroute to Washington they devoted several days to collecting Mississippian fossils in Oklahoma.

During the first week of October 1953, Dr. Cooper, Mrs. Cooper, and Dr. Helen M. Muir-Wood, visiting research scholar from Great Britain, obtained collections from the Devonian in the vicinity of Alpena, Mich., and on the return trip to Washington secured additional Devonian specimens at Thedford, Ontario, and in New York State.

On March 8, 1954, Dr. David H. Dunkle, associate curator, division of vertebrate paleontology, and Dr. Cooper left Washington for Havana, Cuba, for the purpose of examining a large collection of vertebrate and invertebrate fossils that had been offered for sale to the Smithsonian Institution by Dr. Mario Sánchez-Roig. It was not possible to arrive at a mutually acceptable valuation of this collection.

Dr. David Nicol, assistant curator, division of invertebrate paleontology and paleobotany, and his wife proceeded from Washington to Fort Worth and Lake Whitney Dam, Tex., on October 21, 1953, to collect pelecypods and other fossils from the Edwards (Cretaceous) limestone that had been exposed in excavations for the new lake. On the return trip they obtained Cretaceous fossils near Austin and elsewhere in Texas.

Dr. C. L. Gazin, curator, and Franklin L. Pearce, exhibits worker, division of vertebrate paleontology, carried on field work at several Paleocene and Eocene localities in central and southwestern Wyoming. Particular success was achieved in the Paleocene of the Bison basin in the late Wasatchian or Lower Eocene of the Washakie basin and more especially in the Cathedral Bluff tongue of the Wasatchian strata interfingering with the lower part of the Green River lake beds in the northern part of the Bridger or Green River basin. At the close of this field season, Dr. Gazin, accompanied by Mr. Pearce, attended the field conference of the Society of Vertebrate Paleontology held in the Uinta basin of northeastern Utah, and subsequently led a

group of 14 to the Dragon Paleocene exposures in the Wasatch Plateau country of central Utah.

Dr. George Switzer, associate curator, division of mineralogy and petrology, made trips to Colorado and Utah to observe the geological occurrence of uranium minerals in the Colorado Plateau mining district, and to the Fletcher mine, North Groton, N. H., to collect iron and manganese phosphate minerals.

The investigation of the European origins of seventeenth- and eighteenth-century American plow types by Edward C. Kendall, associate curator, division of crafts and industries, was materially advanced by a grant of $1,500 from Deere & Co., which enabled him to attend the International Conference for Research on Ploughing Implements, History and Folklore, held at Copenhagen, June 1 to 5, 1954, and to examine agricultural, industrial, and technical collections in institutions at Stockholm, Oslo, Amsterdam, Brussels, Stuttgart, Munich, Zurich, Rome, Paris, and London. One objective of this trip was information that will assist in reconstructing the types of plows in use at Mount Vernon during the residence there of George Washington.

Frank A. Taylor, head curator, department of engineering and industries, visited 16 museums in West Germany and Berlin (West) at the invitation of the German Federal Government under the America Exchange Programs and subsequently studied museum practices of the Musée de la Marine, Musée de l'Air, Musée de l'Homme, Musée de Conservatoire National des Arts et Métiers, Le Palais de la Découverte, and the Musée Postal in Paris, the Rijksmuseum voor de Geschiedenis der Natuurwetenschappen in Leiden, the Nederlandisch Historisch Scheepvaart Museum, and the Medish Pharmaceutish Museum in Amsterdam, the Norsk Sjøfartsmuseum, Norsk Folkemuseum, Norsk Teknishmuseum, Skimuseet, and Vikingeskipene Museum in Oslo, the Statens Sjöhistoriska Museet, Tekniska Museet, Nordiska Museet and Skansen in Stockholm, and the Science Museum, Victoria and Albert Museum, National Maritime Museum, British Museum (Natural History), and the British Museum (Bloomsbury) in London.

EXHIBITION

The long-contemplated program for modernization of exhibits was initiated under the 1954 Congressional authorization of $360,000. With these funds contracts were let and work actually commenced on the complete renovation of four major exhibition halls.

Eight period rooms for displaying the collection of dresses of the First Ladies of the White House are now under construction in the Arts and Industries Building. Furnishings, significant accessories, and a number of historical architectural features such as mantels

and paneling from the White House rooms in which these dresses were worn will lend realism to dignified room settings befitting the collection and its historical significance. The gowns will be exhibited on plaster figures in rooms equipped with the furniture of the appropriate period. Six alcove wall cases will be utilized in this hall to display objects too small to be clearly seen in the period rooms, including personal belongings of the First Ladies such as jewelry, laces, handkerchiefs, and fans, as well as china used in the White House.

A series of ethnological exhibits ranging geographically from Tierra del Fuego to California and the southwestern States has been designed for early installation, "Native Peoples of Latin America and Southwestern United States," to explain the characteristics of Indian cultures in the Western Hemisphere. Ten life-size groups of Indians showing everyday activities in realistic settings will be installed, as well as 12 alcoves which will contain 5 small-scale diorama models of villages depicting hunting and other activities and 38 panel cases containing materials illustrative of the culture, implements, and achievements of these aboriginal peoples. Ten new wall-case displays illustrating the cultures of the Indians of California, the Navaho, and the Apache have been completed; others are in progress.

Construction work has been commenced on display cases for four habitat groups in the North American mammal hall. The mammals chosen for exhibition in this hall include not only those of outstanding interest to the public but particularly those that played an important role in the lives of our pioneering settlers. Virginia deer, pronghorn antelopes, timber wolves, and the puma will be shown in habitat settings with natural accessories and painted backgrounds.

The bird hall will contain 10 habitat groups of birds chosen for special interest either because of unusual habits or structures they possess. Antarctic penguins, ostrich, bowerbird, passenger pigeon, Carolina parakeet, hoatzin, argus pheasant, Kea parrot, palm chat, and rhinoceros hornbill have been selected for these groups. In 10 topical alcoves and 12 topical wall cases typical representatives of various families of birds of the world will be shown as well as such aspects of birdlife as nests and nest building, migration, courtship, flight, food and feeding habits, plumages, birds famous in legend and literature, and the agricultural and other economic importance of birds to man.

These exhibition funds also enabled the purchase and erection in the west court of the Natural History Building of a Butler-type steel building which provides 8,000 square feet of additional storage space for materials temporarily removed from the exhibition floors. Facilities have also been provided in this building for a working area, enabling the staff of exhibit workers to accomplish the preliminary artistic work and assembly of exhibits while the construction of dis-

play cases is in progress in the halls. All this behind-the-scenes activity is being directed toward the opening of these halls in 1955.

The modernized and wholly revised hall now designated as "Highlights of Latin American Archeology" was completed and formally opened to the public on Pan American Day, April 21, 1954. Representing a noteworthy advance over the previously existing poorly lighted and overcrowded arrangement of archeological specimens, the new exhibits installed present man's cultural development from his earliest beginnings in Latin America to the high civilizations of the Inca, Aztec, and Maya. Thirty exhibit cases are arranged in alcoves corresponding to marginal, tropical forest, circum-Caribbean, Meso-American, and Andean culture areas. These exhibits are designed to illustrate the advance of various cultures from the primitive hunting, fishing, and gathering level of existence to the highly advanced societies practicing well-developed agriculture with complex social and political organizations and skilled technologies.

VISITORS

During the fiscal year 1954 there were 3,262,150 visitors to the Museum buildings, an average daily attendance of 8,937. This is an increase of 141,493 over the total in the previous fiscal year. Included in this total are 240,629 school children, who arrived in 6,616 separate groups. This year among the visitors were special groups such as the 4–H Club, Sea Scouts, Safety Patrol, Stockmen and Cattlemen, who came from Kansas, Wyoming, Montana, Missouri, and Texas. The month of April 1954 drew the largest crowd with 514,214 visitors. May 1954 was the second largest with 458,477 and August 1952 was third with 405,894. Attendance records for the buildings show the following numbers of visitors: Smithsonian Building, 652,078; Arts and Industries Building, 1,748,117; and Natural History Building, 861,955.

BUILDINGS AND EQUIPMENT

Three major projects were undertaken during the year which provided additional storage space for the collections. In the Smithsonian Building 3,250 square feet were made available for storing botanical specimens by the construction of a steel balcony in the east end of the herbarium. An additional 895 square feet of storage space for the fish collections was provided in the Natural History Building when a steel gallery was built in one of the storage rooms. Refrigeration equipment and 665 square feet of additional space were procured for the storage of valuable pelts of fur-bearing mammals. These furs now can be stored properly by regulating the temperature and humidity variation.

CHANGES IN ORGANIZATION AND STAFF

After 35 years of service in Federal agencies, Dr. Edward A. Chapin, curator, division of insects, retired on January 31, 1954. Dr. Chapin was appointed curator on July 1, 1934, as a transfer from the Bureau of Entomology and Plant Quarantine. Oscar L. Cartwright was designated as acting curator February 10, 1954.

A vacancy in the division of engineering was filled on April 5, 1954, by the appointment of Dr. Robert P. Multhauf as associate curator.

Respectfully submitted.

REMINGTON KELLOGG, *Director.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Bureau of American Ethnology

SIR: I have the honor to submit the following report on the field researches, office work, and other operations of the Bureau of American Ethnology during the fiscal year ended June 30, 1954, conducted in accordance with the act of Congress of April 10, 1928, as amended August 22, 1949, "to continue independently or in cooperation anthropological researches among the American Indians and the natives of lands under the jurisdiction or protection of the United States and the excavation and preservation of archeologic remains."

SYSTEMATIC RESEARCHES

M. W. Stirling, Director of the Bureau, studied in the laboratory and prepared descriptions of the archeological materials collected during 1953 on Taboga, Taboguilla, and Uravá islands in the Gulf of Panama, and from the region of Almirante Bay on the north coast of Panama. Technical descriptions of the materials, principally ceramics, were completed and photographs for illustrations made preparatory to publication of the report in the Bureau's Bulletin series. Otherwise most of the time during the fiscal year was occupied with administrative duties.

Dr. Frank H. H. Roberts, Jr., Associate Director of the Bureau and Director of the River Basin Surveys, devoted virtually all his time during the year to the direction and management of the River Basin Surveys. In that connection he reviewed and revised a number of manuscript reports of the results of field investigations by members of the Surveys' staff. In May he attended the annual meeting of the Society of American Archaeology at Albany, N. Y., and as a member of the executive committee presented a set of Archaeological Standards, prepared jointly by him and Dr. Waldo R. Wedel of the U. S. National Museum, which was adopted by the Society.

Dr. Henry B. Collins, anthropologist, continued his Eskimo research and other Arctic activities. From June 24 to August 29 he and his assistant, William E. Taylor, conducted archeological excavations on Cornwallis Island in the Canadian Arctic, the work being sponsored jointly by the Smithsonian Institution and the National Museum of Canada. Cornwallis and the other islands in the northern part of the Arctic Archipelago were uninhabited when discovered by Parry in 1819, and Eskimos have not lived that far north in Canada in historic

times. However, Dr. Collins's excavations have shown that some centuries ago when living conditions were better, Cornwallis Island had been occupied by two distinct groups of prehistoric Eskimos, the Thule and Dorset. The remains visible on the surface—the ruins of solidly built houses of stones, whale bones, and turf—are those of the Thule people. The Dorset occupation, which preceded Thule, was indicated by a buried sod line within and below which were found the stone, bone, and ivory implements characteristic of that culture. Thule material was found above the old sod line. The Dorset artifacts were different in type from the Thule and were also more deeply patinated, being dark brown or gray in contrast to the light cream-colored Thule objects. The same was true of the animal bones; those from the Dorset level were more weathered in appearance, darker colored, and lighter in weight than the relatively fresh-looking bones from the upper part of the midden. The marked difference in the state of preservation of the animal bones and artifacts suggests that after the Dorset occupation the site had been abandoned for some centuries before the Thule Eskimos established their village on the same spot. Samples of sod, soil, charcoal, wood, bones, skin, and other organic materials were collected for possible dating by radiocarbon and pollen analyses.

Dr. Collins prepared a preliminary report describing the 1953 excavations for the Annual Report of the National Museum of Canada. His booklet "Arctic Area," a summary of existing knowledge of the ethnology, archeology, physical anthropology, and linguistics of the Eskimos and Northern Indians, was published by the Comisión de Historia of Mexico as one of the unit studies in its Program of the History of America. Other papers included a critique of the role of Ipiutak in Eskimo culture and an evaluation of the recently developed technique of lexico-statistics in relation to the archeological evidence. This new linguistic technique, which attempts to estimate the time of separation, or age, of related languages on the basis of vocabulary change, produces results for the Arctic area that are in close agreement with the evidence of two other dating techniques—dendrochronology and radiocarbon analysis—as well as with Dr. Collins's previous reconstruction of culture growths, contacts, and population movements in the Eskimo area as deduced from archeology.

Dr. Collins continued to serve as chairman of the directing committee supervising the work on the *Arctic Bibliography*, which the Arctic Institute of North America is preparing for the Department of Defense under contract with Office of Naval Research. The first three volumes of the Bibliography, of approximately 1,500 pages each, were issued by the Government Printing Office in August 1953. They list and summarize the index contents of 20,000 of the more important

publications in all fields of science relating to the Arctic and sub-Arctic areas of the world. The work on the Bibliography is being carried out by a staff of 12 bibliographers and scientists under the direction of Miss Marie Tremaine. Most of the work has been done at the Library of Congress but the collections of the New York Public Library, Smithsonian Institution, Harvard University, and some 60 other large libraries in the United States and Canada have also been utilized. In addition to books and monographs, the Bibliography lists and describes material published in more than 1,400 scientific journals and serial publications in English, Russian, and other languages. Titles of foreign-language publications are given in the original and in English, with description of the contents in English. Covering all fields of science for all the Arctic and sub-Arctic, the *Arctic Bibliography* is now recognized as the most comprehensive regional bibliography ever assembled. Volume 4, of approximately 1,500 pages, is scheduled for publication in August 1954. Dr. Collins made arrangements with the Department of the Air Force, which has supported the work for the past two fiscal years, for continuation of the Bibliography project in 1954–55, and for the printing of volume 5, the material for which was delivered to the Government Printing Office in June 1954.

On June 21, Dr. Collins and three assistants, William E. Taylor, Jr., Dr. J. Norman Emerson, and Eugene Ostroff, left to conduct archeological work in Hudson Bay. The expedition is being sponsored by the National Museum of Canada, the National Geographic Society, and the Smithsonian Institution. The party was flown by the Royal Canadian Air Force from Montreal to Coral Harbour, on Southampton Island, and will remain until September, investigating prehistoric Eskimo sites on Southampton and Coats Islands.

During July and August of 1953, Dr. John P. Harrington was in the region of Santa Barbara, Calif., continuing his studies of the Chumash Indians, the most advanced tribe of the State. He also made a special study of place names as recorded by the Cabrillo expedition of 1542 and by the Portola and Anza expeditions of 1769 and 1776, respectively. A great majority of these names were located during the field study. On returning to Washington Dr. Harrington continued the preparation of a detailed report on his findings.

At the beginning of the fiscal year Dr. Philip Drucker, anthropologist, was in Washington continuing his studies of Olmec archeological materials from southern Mexico. He also began preparations for a field trip to the coast of British Columbia and southeast Alaska in order to continue his study of modern intertribal Indian organization. Early in September he went to British Columbia to carry on this research. A grant from the Arctic Institute of North America made this work possible. Toward the end of the calendar year a supple-

mentary grant from the American Philosophical Society enabled him to proceed to southeast Alaska to complete his study of the Alaska Native Brotherhood. In mid-March he returned to Washington. Since his return Dr. Drucker has worked on the final report on these intertribal organizations and on related problems of acculturation on the Northwest Coast. He also devoted considerable time to a committee study of the research potential of the Smithsonian Institution. During the fiscal year Drucker prepared two papers for publication, one on "Origins of Northwest Coast Culture" and the other with Eduardo Contreras on "Site Reconnaissance in Olmec Territory."

RIVER BASIN SURVEYS

(Prepared by Frank H. H. Roberts, Jr.)

The River Basin Surveys, instituted in the autumn of 1945 as a unit of the Bureau of American Ethnology to carry into effect a memorandum of understanding between the Smithsonian Institution and the National Park Service, providing for the salvage of archeological and paleontological materials which will be lost as a result of the nation-wide program for flood control, irrigation, hydroelectric and navigation projects sponsored by the Federal Government, State, and private agencies, continued its operations during the year. As in previous years the work was carried on in cooperation with the National Park Service and the Bureau of Reclamation of the Department of the Interior, the Corps of Engineers, Department of the Army, and a number of State and local institutions. During the fiscal year 1953–54 the investigations were financed by transfer of $71,495 from the National Park Service to the Smithsonian Institution. Included in that sum were $64,500 for work in the Missouri Basin and $6,995 for other areas. An additional carry-over of $3,409 made the over-all total available for obligation during the fiscal year $74,904. That sum was approximately only 43 percent of that available for the preceding year and made necessary a sharp reduction in the work of the River Basin Surveys.

Activities in the field consisted for the most part of reconnaissances or surveys for the purpose of locating sites that will be involved in construction work or are so situated that they will eventually be covered by the waters of the reservoirs formed by the completion of dams. There also was some excavation, but because of lack of funds the digging was on a small scale. In several reservoir areas intensive test surveys were carried on. The parties concerned with that activity visited sites previously located and recorded but about which there was meager information. At each such site a number of test pits were dug and artifacts were collected in order to determine the cultural affiliations of the remains found there. Straight reconnaissance parties

visited two reservoir basins located in one State. The intensive test surveys were made in three reservoir areas in two States. At the end of the fiscal year excavations were completed or were under way in four reservoir basins in two States. During the course of the year there were four excavating parties in the field, three of them in areas where investigations had previously been made. By June 30, 1954, areas where archeological surveys had been made or excavations carried on since the start of the program in 1946 totaled 243 in 27 States. One lock project and four canal areas also have been investigated. During the course of the work a total of 4,345 archeological sites have been recorded and of that number 852 have been recommended for excavation or further testing. Preliminary appraisal reports were completed for all the reservoirs surveyed and further supplemental reports have been prepared where additional reconnaissances have resulted in the discovery of further sites. During the course of the year seven such reports were issued. The total number distributed since the start of the program is 179. Where several reservoirs form a unit in a single drainage subbasin, the information on all was included in a single report. Consequently, the 179 mimeographed pamphlets contain information on all the 243 reservoirs thus far surveyed. Excavations carried on during the year brought the total for reservoir projects where such investigations have been made to 44 located in 17 different States. The total number of sites thus far excavated or extensively tested totals 324. Fourteen manuscript reports on previous excavation work were completed during the year and are ready for publication. One major technical report was in final page-proof form at the end of the fiscal year and will appear as Bureau of American Ethnology Bulletin 158. In view of the necessary reduction in force because of lack of funds, no paleontological field work was carried on during the year. The paleontologist who formerly was a member of the River Basin Surveys staff was lent by the National Park Service for a period of three weeks to the Missouri Basin Project of the River Basin Surveys in order that he might complete the identification of specimens previously collected.

The reservoir projects which have been surveyed for archeological remains as of June 30, 1954, were distributed as follows: Alabama, 1; California, 20; Colorado, 24; Georgia, 5; Idaho, 11; Illinois, 2; Kansas, 10; Kentucky, 2; Louisiana, 2; Minnesota, 1; Mississippi, 1; Montana, 15; Nebraska, 28; New Mexico, 1; North Dakota, 13; Ohio, 2; Oklahoma, 7; Oregon, 27; Pennsylvania, 2; South Dakota, 9; Tennessee, 4; Texas, 19; Virginia, 2; Washington, 11; West Virginia, 2; and Wyoming, 22.

Excavations have been made or were under way in reservoir basins in: California, 5; Colorado, 1; Georgia, 4; Kansas, 3; Montana, 1; Nebraska, 1; New Mexico, 1; North Dakota, 4; Oklahoma, 2; Oregon,

3; South Carolina, 1; South Dakota, 3; Texas, 7; Virginia, 1; Washington, 4; West Virginia, 1; and Wyoming, 2. The foregoing figures include only the work of the River Basin Surveys or that in which there was direct cooperation with local institutions. Projects that were carried on by local institutions under agreements with the National Park Service are not included because complete information about them is not available.

During the year the River Basin Surveys continued to receive helpful cooperation from the National Park Service, the Bureau of Reclamation, Corps of Engineers, and various State and local institutions. Temporary office and laboratory space were provided at some of the projects, transportation and guides were furnished at others, and in several cases mechanical equipment was made available by the construction agency. Detailed maps of the reservoirs under investigation were supplied by the agency concerned. The field personnel of the various agencies was extremely cooperative in assisting the River Basin Surveys men and because of that help much more was accomplished than would have been possible otherwise. The National Park Service continued to function as the liaison between the various agencies both in Washington and in the field. It also was responsible for the preparation of estimates and justifications and the procurement of funds for carrying on the program. The cooperation of Park Service personnel was a definite aid in all phases of the operations.

The main office in Washington directed and supervised the program in the East and South while the field headquarters and laboratory in Lincoln, Nebr., directed the work in the Missouri Basin. The materials collected by Missouri Basin parties were handled at the Lincoln laboratory while those from the East and South were processed in Washington.

Washington Office.—Through the fiscal year the main headquarters of the River Basin Surveys continued under the direction of Dr. Frank H. H. Roberts, Jr. Carl F. Miller and Ralph S. Solecki were based at that office although Mr. Solecki was on leave without pay during most of the year. From July 1953 until May 12, 1954, Mr. Solecki was in Iraq as a Fulbright Scholar, conducting excavations financed jointly by the Iraq Government and the Smithsonian Institution. On May 12, 1954, he returned to active duty with the River Basin Surveys and made a reconnaissance of two projects on the Cumberland River in Tennessee. On June 28 he resigned to resume his graduate studies in anthropology.

Mr. Miller spent the greater part of the year in the office preparing reports based upon field investigations made in previous years. In August he completed a brief preliminary report of a rapid reconnaissance of the Cheatham Lock and Dam, Old Hickory, and Carthage

Reservoirs in Tennessee. He completed one manuscript pertaining to the Siouan occupation of the Roanoke River area in southern Virginia. This research was an outgrowth of his studies in connection with the results of his excavations at the John H. Kerr (Buggs Island) Reservoir. In addition Mr. Miller worked on his detailed technical report for the John H. Kerr Reservoir, completing the analysis, classification, and comparison of specimens obtained from a number of different sites. In May 1954, Mr. Miller made a brief trip to a site along the old Chesapeake and Ohio Canal near Sharpsburg, Md., where traces of an Indian occupation were being uncovered by erosion. On that trip Mr. Miller accompanied Dr. John M. Corbett and John L. Cotter of the Archeological Branch, History Division, National Park Service. At the close of the fiscal year Mr. Miller was busy working on his John H. Kerr report.

Missouri Basin.—The Missouri Basin Project continued to operate throughout fiscal 1954 from the field headquarters at the University of Nebraska and the laboratory in the business section of Lincoln, Nebr. Robert L. Stephenson served as acting chief of the project from July 1 to June 14 when he was promoted to chief. Activities throughout the year were greatly reduced because of the lack of funds. The permanent staff had been cut from 21 to 11 on July 1 and during the year was further reduced to 8. Consequently field activities were on a much smaller scale. However, all four phases of the salvage program as originally drawn up were in progress. Some reconnaissance work was done consisting of intensive survey and testing of archeological sites in two reservoirs and reconnaissance of a portion of a third reservoir. The second phase, the excavation of selected sites, continued at three sites in three reservoir areas while a fourth field party did some digging at four sites in a single reservoir area. The third phase of the program, the processing of the collections obtained from the digging, the analysis and study of the materials, and the preparation of general and technical manuscripts on the results, was carried on actively by the members of the staff. Phase four, the publication and dissemination of scientific and popular reports, showed some accomplishment. Several short papers were published during the year and one long report was in the final stages of printing at the Government Printing Office. By the end of the fiscal year 10 manuscripts had been completed and submitted for publication.

During the year six River Basin Surveys field parties operated in the Missouri Basin. In July, August, and September one party visited 57 previously located sites in the Fort Randall Reservoir and carried on test excavations in 18 of them. Test pits were dug and surface collections of artifacts were made at the other 39 sites. Many of them were actually in the process of being inundated by the rising waters of the reservoir at the time the party visited them. A total of 5 previously

unrecorded sites were located in addition to the 57 examined and sample collections were made from each. During August, September, and October another party made an intensive reconnaissance and tested major sites in the Oahe Reservoir area in north central South Dakota. The purpose of that party was to locate new and unrecorded sites in the area, to visit all the old sites reported in previous years in order to reevaluate them in terms of new information, and to test extensively those which seemed to warrant full-scale exploration in order to determine the minimum amount of digging necessary to obtain a fair sample from each. The party accomplished all three objectives. Eleven previously unknown sites were recorded and tests made in them. A total of 89 previously located sites were revisited and tests of varying intensiveness were made in 45.

In May 1954 a reconnaissance party returned to the Fort Randall Reservoir to obtain further information from several additional sites for which the data were not conclusive. The party found that several of those scheduled for study had already gone under water but by the end of the fiscal year 13 had been visited and more or less intensively investigated. Extensive excavations were carried out at three of them. At one a circular house and an exterior cache pit were dug, and at another stratified camp remains were trenched. At the end of the year the party was clearing debris from the ruins of an earth lodge. A second party also went to the Fort Randall Reservoir in May to complete investigations at a large earth-lodge village which had been occupied by at least two groups of prehistoric Indians and where considerable work had been done during two previous seasons. At the end of the year that party was still in the field, having excavated earth lodges, palisade trenches, and cache pits, establishing not only the two occupations previously noted but a third one as well. The evidence obtained indicates that the three occupations took place at various times between A. D. 1500 and 1700. At the end of the year the water of the reservoir had already risen to the lower edges of the site and it was expected that by mid-July the entire area would be under several feet of water.

A third party went to the Garrison Reservoir in North Dakota in May and resumed excavations at the site of Fort Berthold II where extensive digging had been done during the 1952 field season. Shortly after arriving at the location the River Basin Surveys party joined forces with one from the State Historical Society of North Dakota which was working under a cooperative agreement with the National Park Service. As a single unit, the combined group completed the excavation of all features of the site of Fort Berthold II, which was occupied by both fur traders and American military forces from about 1858 to 1890. The group then turned its attention to the remains of the adjacent Indian village where considerable digging had been done

in previous years by the North Dakota Society. During the progress of the operations the remains of Fort Berthold I, an earlier fur-trading post dating from 1845 to 1862, were located and uncovered. The original post had been burned by the Sioux Indians and earth lodges erected over the site. For that reason its location was long in doubt and it was a fortunate circumstance that it was found because much previously unknown information on the fur trade during the middle nineteenth century was obtained. At the end of the fiscal year the joint field party was occupied with the remains of Indian houses located between the two trading posts. No further work will be possible there after the 1954 field season because the Garrison Reservoir was to cover it before the end of the summer. Heavy equipment was used with marked success during the digging at the Garrison Reservoir. By using a road grader and a bulldozer it was possible to define for the first time the entire course of the palisade which originally enclosed the oldest portion of the Indian village. As a result of the investigations, a complete detailed map of the entire Indian village and the two Fort Bertholds could be made.

The fourth party went to the Jamestown Reservoir area in east-central North Dakota early in June. It devoted three weeks to a survey of the upper end of the basin, locating five new sites of which three were tested. The remaining time was spent digging at the location of a former earth-lodge village where excavations were started during the 1952 field season. The work of the 1954 season determined the limits of the village and added enough new information to make possible a fairly accurate description of early eighteenth century Mandan culture in that part of the Plains. There were other sites in the area which merited further study but since flooding was already well under way, no additional work could be done. The party had returned to the headquarters at Lincoln by the end of the fiscal year.

During July two of the temporary staff members assisted a joint party from Kansas State College and the Laboratory of Anthropology of the University of Nebraska in excavations at a site in the Tuttle Creek Reservoir in northeastern Kansas. The site was partially dug by a River Basin Surveys group in June 1953 but it was not possible to complete the work that had been started before the party had to return to the Lincoln headquarters. Since portions of an earth lodge and other village features had been uncovered, it was essential to finish those investigations and to accomplish that end the cooperative effort was organized under the sponsorship of Kansas State College. The information obtained helps to explain a little-known phase of the history of that particular district.

During the year the Laboratory at Lincoln processed 27,965 specimens from 181 sites in 3 reservoir areas and 5 unassignable sites. A total of 5,346 catalog numbers were assigned to the series of specimens.

As of June 30, 1954, archeological materials from 1,496 sites in reservoir areas and from 43 sites outside reservoir areas where loss from other construction was imminent had been cataloged. The work in the laboratory also included: reflex copies of record sheets, 9,488; photographic negatives, 2,160; photographic prints, 12,367; prints mounted to illustrate manuscripts, 220; photographic transparencies mounted in glass, 188; drawings, tracings, and maps, 211; pottery vessels restored, 5; pottery vessel sections restored, 145; specimens drawn for illustration, 57; plate layouts for manuscripts, 122; restorations of human crania, 10.

Interpretative displays showing the scope and results of archeological investigations in the Missouri Basin were installed from time to time in the windows of the laboratory in the business section of Lincoln and in one of the main banks of the city. A special display explaining the archeological salvage program was also installed at the Nebraska State Fair held at Lincoln during September. The latter attracted considerable attention from visitors to the fair.

Paul L. Cooper, archeologist, was at the Lincoln headquarters at the beginning of the fiscal year and did not make any field trips during the summer of 1953. He devoted the months at the laboratory to the completion of a summary report of the Missouri Basin salvage program during the calendar years 1950–51. He also completed for publication a technical report on the excavations made at the Heart Butte Reservoir during a previous season. In addition he worked on a report of investigations in three burial mounds, two near the location of the former Wheeler Bridge and the White Swan Mound which was in the area of the spillway of the Fort Randall Dam. A report on the human skeletal material is being prepared by Dr. Marshall T. Newman of the U. S. National Museum and will appear as an appendix to the archeological report. Mr. Cooper participated in the sessions of the Eleventh Conference for Plains Archeology held at Lincoln in November. On May 16 he proceeded to the Fort Randall Reservoir area in South Dakota and directed an intensive test survey of 13 sites and carried on excavations in 3 sites. Some of them had already been partially inundated and others were flooded shortly after they were investigated. At the end of the fiscal year he was continuing his operations in the Fort Randall area.

Robert B. Cumming, archeologist, was at the headquarters in Lincoln at the start of the fiscal year. On July 27 he left for the Fort Randall Reservoir area in charge of a party which was to make intensive test surveys during the period extending to September 12. After instructing the party as to the proper procedure, he returned to the Lincoln headquarters and devoted his time to analyzing and preparing a report on the results of his previous investigations in that area. During the time he was at the laboratory Mr. Cumming completed a

technical report on the excavations which he had made at the Tuttle Creek Dam in Kansas the previous year. He also prepared a special report concerning the archeological potentialities of the Powder River Basin in Wyoming. In November he participated in the Eleventh Conference for Plains Archeology, presenting 3 papers. On May 17 he returned to the Fort Randall Reservoir area and resumed excavations at a site where work had been done during two previous field seasons. On May 31 he returned to the field headquarters leaving his party under the direction of Harold A. Huscher. Mr. Cumming resigned from the River Basin Surveys on June 6 after having been with the Missouri Basin Project from its inception in 1946.

Harold A. Huscher, field assistant, was in direct charge of the field party in the Fort Randall area from July 27 to September 12. He worked under the general supervision of Robert B. Cumming. During the time he was in the field he supervised the testing of 18 sites and located 5 which were previously unrecorded. After returning to the field headquarters at Lincoln, Mr. Huscher completed a report on the summer's work. He returned to the university for graduate work during the fall and winter and rejoined the River Basin Surveys in June when he took charge of the excavating party, which had been under Mr. Cumming's direction, in the Fort Randall area. At the end of the fiscal year, Huscher and his group were busy stripping a large area and uncovering house remains at the important Oldham site.

G. H. Smith, archeologist, rejoined the staff of the Missouri Basin Project in May and proceeded to the Garrison Reservoir area in North Dakota where he resumed excavations at the site of Fort Berthold II and Like-a-Fishhook village. Smith was subsequently joined by Alan R. Woolworth, curator of the Museum of the State Historical Society of North Dakota, and his group of laborers and the combined parties worked as a unit in carrying on the excavations. In addition to completing the investigation of Fort Berthold II which Smith had started in the summer of 1952, various Indian house remains were cleared and the original Fort Berthold, which was established by the American Fur Company in 1845, was located. In addition to those activities, the general base map of the entire area which had been started in 1952 was completed. This provides for the first time an adequate historical and archeological map of the entire site. The joint field party was still at work there at the close of the fiscal year. During the year Mr. Smith completed the detailed technical report on the excavations which he made in a previous season at the site of Fort Stevenson, also in the Garrison area.

During the fiscal year Robert L. Stephenson, chief of the Missouri Basin Project, devoted the major portion of his time to directing the operations of the project. In addition, however, he prepared a series

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of summary statements on the 7 years of the project's activities. He also virtually completed a technical report, "Archeological Investigations in the Whitney Reservoir Area, Hill County, Texas," and prepared an article on salvage archeology for the Bible Archeological Digest and a paper, "Taxonomy and Chronology in the Central Plains-Middle Missouri River Area," which was published in the Plains Anthropologist, No. 1. He also took an active part in the Eleventh Conference for Plains Archeology and presented a paper at the Sixty-fourth Annual Meeting of the Nebraska Academy of Sciences in Omaha. He gave the principal address at the Semiannual Meeting of the Missouri Archeological Society held in Kansas City in May. In June he made a tour of inspection, visiting the various field parties working in the Missouri Basin.

Richard Page Wheeler, archeologist, was at the field headquarters at the beginning of the fiscal year working on reports covering his previous investigations. On August 13 he proceeded to the Oahe Reservoir area in South Dakota where until October 9 he, with two assistants, made an intensive survey of the lower section of the area. In the course of the work 82 previously recorded sites were visited and 16 new ones were discovered. In a number of instances material new to the Oahe area was noted and one of the sites gave evidence of five successive occupations. After returning to headquarters Wheeler devoted the winter and spring months to work on technical reports concerning excavations made in previous seasons at the Angostura, Boysen, and Keyhole reservoirs in South Dakota and Wyoming. He completed two articles; one, "Selected Projectile Point Types of the United States: II," was published in the Bulletin of the Oklahoma Anthropological Society, vol. 2, while the other, "Two New Projectile Point Types: Duncan and Hanna Points," was printed in the Plains Anthropologist, No. 1. He participated in the Eleventh Conference for Plains Archeology and attended the Sixty-fourth Annual Meeting of the Nebraska Academy of Sciences where he presented a paper, "New Contributions to the Archeology of Oahe Reservoir." At that time he was elected chairman of the anthropology section for the Sixty-fifth Annual Meeting of the Academy. On June 3 Wheeler proceeded to the Jamestown Reservoir in North Dakota and resumed excavations at a site where he dug in 1952. While that work was going on he also made a survey of the upper end of the reservoir basin. The Jamestown investigations were completed and Wheeler returned to the Lincoln Office on June 30.

Tennessee.—The only work done in Tennessee during the year was the detailed surveys of the Cheatham Lock and Dam and Old Hickory Lock and Dam projects on the Cumberland River near Nashville. A brief preliminary reconnaissance of the area in June 1953 indicated that a more extended examination was warranted and arrangements

were made for further investigations. During the period from May 17 to June 2 both projects were covered on foot, by vehicle, by boat, and by two flights over them in light planes for photographic purposes. The Cheatham Dam is located 35 river miles below Nashville and the reservoir it impounds will be about 67.5 river miles long. Twenty archeological sites were found in the area but only one will be affected by the flooding of the basin. The others, lying on the second and third bottoms or higher slopes will not be in danger. The one which will be involved represents an Archaic horizon and test digging in it was recommended. At one of the higher-level locations a fluted point was found in association with a series of nondescript flakes and chips. This indicates that the Paleo-Indian was in the area, although there may not be a true site for that horizon. The Old Hickory Dam is located 25 river miles upstream from Nashville and 2 river miles below the town of Old Hickory. The reservoir which it forms will extend 97.3 river miles above it. Twenty-three archeological sites were found within the limits of the proposed pool. The sites comprise 18 Archaic, 1 Middle Mississippi, 1 cave of undetermined cultural affiliations, although probably Middle Mississippi, and 3 which did not give sufficient surface evidence to permit identification. Test excavations were recommended for four of the sites.

Cooperating institutions.—As in previous years, a number of State and local institutions cooperated in the Inter-Agency Salvage Program. In a few cases State groups carried on independently, but correlated their activity closely with the over-all operations. Most of the projects, however, were under agreements between the National Park Service and the various agencies. In Indiana the Historical Society continued to include surveys of proposed reservoir areas in its general program for archeological investigations in that State and made reports on the results of its work. The Ohio State Archeological and Historical Society again conducted salvage operations in several localities. The Alabama Museum of Natural History and the Birmingham Anthropological Society voluntarily investigated the situation along the Coosa River Valley where a series of dams was planned by the Alabama Power Company. Louisiana State University made a survey of the construction area for a new river channel at the mouth of Old River in Louisiana. The cooperative efforts of the Kansas State College and Laboratory of Anthropology of the University of Nebraska at the Tuttle Creek Dam have already been discussed.

Institutions working under agreements with the National Park Service and the projects undertaken were: the University of California, Berkeley, in the summer of 1953 completed the excavation of sites in the Nimbus and Redbank Reservoir basins, obtaining important data from the latter, and in the late spring of 1954 began investigations in the Monticello Reservoir basin; the University of Missouri

excavated in the Table Rock Reservoir area on the White River in Missouri during the summer of 1953 and returned to the same area in June 1954; during the first quarter of the year the University of Kansas completed excavation at four sites in the Fort Randall Reservoir basin in South Dakota; the Nebraska State Historical Society started a series of excavations on June 10 at the Crow Creek site in the Fort Randall Reservoir basin and had just gotten well under way at the end of the fiscal year; the University of Nebraska State Museum completed work on a portion of one site in the Medicine Creek Reservoir area in western Nebraska at the end of July and then moved to the Big Sandy project in southwestern Wyoming where a number of sites were investigated during the month of August, paleontological studies being conducted on a voluntary basis at several locations in the Missouri Basin by the same organization; as previously noted, the State Historical Society of North Dakota resumed its activities at the Garrison Reservoir, North Dakota, in May and was still at work at the end of the fiscal year; the University of Oklahoma was preparing to start surveys late in June at the Norman, Foss, and Fort Cobb reservoir projects in that State; the University of Oregon excavated at sites in The Dalles Reservoir on the Oregon side of the Columbia River in the summer of 1953 and returned to the same locality for the 1954 field season; a joint party of the W. H. Over Museum of the University of South Dakota and South Dakota Archeological Commission completed excavation at the Spotted Bear and Cottonwood sites in the Oahe Reservoir area in South Dakota in the first quarter of the year and in June returned to the same basin and started digging at the Swan Creek site; the University of Utah was preparing to start a basin-wide survey in the Missouri Basin at the close of the fiscal year; the University of Washington carried on excavations at the Wakemap Mound on the Washington side of the Columbia River at The Dalles Reservoir project during the first quarter and returned to the same location in June. In the case of the three cooperating groups in the Missouri Basin, the River Basin Surveys assisted the field activities by the loan of vehicles and other equipment.

ARCHIVES

Mrs. Margaret C. Blaker, archivist for the Bureau, continued her program of reorganizing the manuscript and photographic collections in addition to the usual daily routine.

From time to time the photographic and manuscript collections of the archives are enriched by gifts from persons who find old or rare items in their possession. During the past fiscal year among the more important additions received were the following:

About 100 prints and 16 glass-plate negatives of California Indians made ca. 1889–95 by the Rev. H. C. Meredith, a missionary. Received through John Witthoft, Pennsylvania State Museum.

Twenty mounted stereoscopic views of ethnological subjects made on the Geographical Explorations and Surveys West of the 100th Meridian ("Wheeler Surveys") of 1871, 1873 and 1874. Gift of Vincent McMullen, Washington, D. C.

Thirty photographic prints of Crow Indians made by Dr. Dixon on the Wannamaker expedition to the Plains, 1909–13. Received through Dr. Georg Neumann.

The following photographs were received through loan for copying:

Fifty-seven original prints of Kiowa and Comanche Indians made in and around Fort Sill, Okla., on the Kiowa Reservation in the 1890's by various photographers, including George W. Bretz. Lent by F. B. Shuler, Hamilton, Ohio.

Photographic print (copy), a portrait of Billy Bowlegs, Seminole leader, thought to have been made in 1852. Lent by H. P. Kennedy, Tampa, Fla.

Photograph of a Kansa delegation to Washington in winter of 1909–10. Lent by Vincent McMullen, Washington, D. C.

Identifications of a number of portraits of Kiowa and Comanche Indians living on the Kiowa Reservation in the 1890's were supplied by Arthur R. Lawrence, Lawton, Okla., who obtained the information from descendants or contemporaries of the individuals portrayed.

ILLUSTRATIONS

During the past fiscal year, E. G. Schumacher, illustrator, continued the preparation of illustrations, charts, maps, and diagrams for publications of the Bureau of American Ethnology, including those of the River Basin Surveys. Time was also taken to prepare and execute many miscellaneous diagrams, drawings, and other illustrative materials for different branches of the Institution.

EDITORIAL WORK AND PUBLICATIONS

There were issued 1 Annual Report and 3 Bulletins, as follows:

Seventieth Annual Report of the Bureau of American Ethnology, 1952–1953. ii+33 pp. 1954.

Bulletin 152. Index to Schoolcraft's "Indian Tribes of the United States," compiled by Frances S. Nichols. vi+257 pp. 1954.

Bulletin 154. River Basin Surveys Papers: Inter-Agency Archeological Salvage Program. Nos. 1–6. xviii+336 pp., 56 pls., 40 figs. 1953.

- No. 1. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri River Basin Archeological Survey in 1948, by Waldo Wedel.
- No. 2. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri River Basin Archeological Survey in 1949, by Waldo R. Wadel.
- No. 3. The Woodruff Ossuary, a prehistoric burial site in Phillips County, Kansas, by Marvin F. Kivett.
- No. 4. The Addicks Dam sites:
 - I. An archeological survey of the Addicks Dam basin, Southeast Texas, by Joe Ben Wheat.
 - II. Indian skeletal remains from the Doering and Kobs sites, Addicks Reservoir, Texas, by Marshall T. Newman.

No. 5. The Hodges site:
I. Two rock shelters near Tucumcari, New Mexico, by Herbert W. Dick.
II. Geology of the Hodges site, Quay County, New Mexico, by Sheldon Judson.

No 6. The Rembert Mounds, Elbert County, Georgia, by Joseph R. Caldwell.

Appendix. List of River Basin Surveys reports published in other series.

Bulletin 156. The Iroquois Eagle Dance, an offshoot of the Calumet Dance, by William N. Fenton, with an analysis of the Iroquois Eagle Dance and songs, by Gertrude Prokosch Kurath. vi+324 pp., 28 pls., 36 figs. 1953.

The following publications were in press at the close of the fiscal year:

Bulletin 157. Anthropological Papers, Nos. 43–48.
No. 43. Stone Monuments of the Río Chiquito, Veracruz, Mexico, by Matthew W. Stirling.
No. 44. The Cerro de las Mesas offering of jade and other materials, by Philip Drucker.
No. 45. Archeological materials from the vicinity of Mobridge, South Dakota, by Waldo R. Wedel.
No. 46. The original Strachey vocabulary of the Virginia Indian language, by John P. Harrington.
No. 47. The Sun Dance of the Northern Ute, by J. A. Jones.
No. 48. Some manifestations of water in Mesoamerican art, by Robert L. Rands.

Bulletin 158. River Basin Surveys Paper No. 7. Archeological Investigations in the Oahe Dam area, South Dakota, 1950–51, by Donald J. Lehmer.

Bulletin 159. The Horse in Blackfoot Indian culture, with comparative material from other western tribes, by John C. Ewers.

Bulletin 160. A ceramic study of Virginia archeology, by Clifford Evans, with an appendix on an analysis of projectile points and large blades, by C. G. Holland.

Publications distributed totaled 21,229, as compared with 38,596 for the fiscal year 1953.

COLLECTIONS

Acc. No.

194273. Casts of vessels and figurines excavated at Cerro de las Mesas, Veracruz, Mexico, in 1941. Original material collected by Dr. M. W. Stirling, 1948.

194274. Potsherds and figurines excavated at La Venta, Tabasco, Mexico. Collected by Philip Drucker, 1942.

195872. Twenty-five pottery vessels from Veraguas, Panama. Collected by Dr. M. W. Stirling, 1951.

200850. Nine gold, copper, and pottery objects from Panama (1951), and 2 archaic pottery figurines from Mexico (1946). Collected by Dr. M. W. Stirling.

201030. Eleven stone beads from Veraguas, Panama (1949), and 1 effigy bird from Veracruz, Mexico. Collected by Dr. M. W. Stirling.

201671. Pottery vessel from Panama. Collected by Dr. M. W. Stirling, 1951.

202489. Twenty-six ethnographical specimens from a sub-Andean Indian tribe of Colombia, S. A.

196412. Miscellaneous bones of 7 species of mammals from Sapeloe Island, Ga., carbon-14 determined age about 3,800 years. Through Dr. A. J. Waring.

199026, 201160. One snake, 1 gecko, 3 grasshoppers, and 6 marine mollusks from Taboga Island, Panama Bay, collected by Dr. M. W. Stirling, 1953.

FROM RIVER BASIN SURVEYS

199132. Eighteen archeological specimens from 4 sites in Albeni Falls Reservoir area, Pend Oreille River, Bonner Co., Idaho. Collected by Joel L. Shiner, 1952.

199133. Ninety archeological specimens from 2 sites in Cachuma Reservoir area on Santa Ynez River, Santa Barbara Co., Calif. Collected by Albert D. Mohr, 1952.

199134. 650 archeological specimens from Site 45 BN 3, McNary Reservoir, Columbia River, Benton Co., Wash. Collected by Dr. Douglas Osborne, 1948.

199267. Two bird bones from North-South Dakota area. Through Robert L. Stephenson.

199210, 200377. Thirty fresh-water mussels from archeological sites in the Missouri Basin. Through Robert L. Stephenson.

199430. Fifty-seven Oligocene fossil mammal specimens from Canyon Ferry Reservoir area in Montana, collected by Dr. Theodore E. White, June 1953.

200125. Pottery, stone, bone, and shell artifacts and human skeletal material from the Woodruff Ossuary, Phillips Co., Kans. Collected by Marvin L. Kivett, 1946.

MISCELLANEOUS

Dr. Frances Densmore, Dr. John R. Swanton, Dr. Antonio J. Waring, Jr., and Ralph S. Solecki continued as collaborators of the Bureau of American Ethnology.

On April 30, 1954, Dr. John P. Harrington retired after 39 years' service as ethnologist on the staff of the Bureau. Upon his retirement he was appointed research associate of the Smithsonian Institution and will continue his linguistic studies in that capacity.

Information was furnished during the past year by members of the Bureau staff in reply to numerous inquiries concerning the American Indians, past and present, of both continents. The increased number of requests from teachers, particularly from primary and secondary grades, from Scout organizations, and from the general public, indicates a rapidly growing interest in the American Indian. Various specimens sent to the Bureau were identified and data on them furnished for their owners.

Respectfully submitted.

M. W. Stirling, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the Astrophysical Observatory

SIR: I have the honor to submit the following report on the operations of the Astrophysical Observatory for the fiscal year ended June 30, 1954:

The Observatory includes two research divisions: (1) The Division of Astrophysical Research, which since 1890 has carried on studies related to solar radiation, and (2) the Division of Radiation and Organisms founded in 1929 for studies of the effects of radiation upon plants and animals. No alterations in the observatory buildings other than minor repairs have been made. Air conditioning was installed in the instrument shop to protect precision equipment from corrosion.

On September 11, 1953, the Astrophysical Observatory suffered an irreparable loss in the sudden death of William H. Hoover, Chief of the Division of Astrophysical Research. Mr. Hoover was outstanding in research accomplishments and in his comprehensive knowledge of the details of our work. His loss is sincerely mourned by all his associates. No successor has as yet been chosen.

DIVISION OF ASTROPHYSICAL RESEARCH

At the Observatory's two high-altitude observing stations, Montezuma in northern Chile and Table Mountain in southern California, certain developments concerning the quality of the skies are somewhat disturbing. Twenty-five miles to the north of Montezuma, extensive copper-mining interests have recently changed from electrolytic to smelting methods. As a result great quantities of gas and smoke are released to the surrounding atmosphere. It is hoped that the prevalent strong afternoon trade winds will dissipate much of this smoke. At Table Mountain, a gradual increase of haze probably associated with the smog of southern California has been noted.

Work in Washington.—The time of the staff, in addition to furnishing requested information to interested scientists and others, was spent as follows:

1. Correcting the proofs of volume 7 of the Annals of the Astrophysical Observatory and checking the many hundreds of thousands of digits included in the tables. Some time was also required in preparation for the final issuance of the 9th Revised Edition of the Smithsonian Physical Tables which occurred in June 1954.

2. Analyzing, appraising, recomputing where doubtful, and tabulating the solar-constant record as received from the field stations, for the year 1953.

3. Previous reports have mentioned the radiation measurements made by the division under contract with the Office of the Quartermaster General in connection with Quartermaster Corps researches to determine the causes for the deterioration of exposed textiles. The work was begun early in 1945 with the preparation of proper equipment to measure the total sun and sky radiation received upon the fabrics, both in the open, and under various filters. Actual measurements began at Camp Lee, Va., in December 1945 and continued through November 1947. To determine the effect of a moist, sea-level environment, similar exposures and measurements were made at Miami, Fla., during 1948 and 1949. These also included spectrobolometric measurements made with equipment formerly used in solar-constant measurements at Tyrone, N. Mex. In 1950–53 similar exposures and measurements were made at Montezuma, Chile, a dry, high-altitude station. A summary of all these measurements is given in volume 7 of the Annals, chapter 6. The contract between the Office of the Quartermaster General and the Smithsonian Institution expired September 30, 1953. Subsequent to this a complete inventory of all equipment acquired was prepared. Through the cooperation of the Quartermaster Corps, the Smithsonian Institution was permitted to purchase at reasonable cost the bulk of this equipment for continued use in the Astrophysical Observatory.

4. In addition to routine calibrations of instruments used in the field, the following calibrations were made for others:

(*a*) Mr. Mateer, of the Meteorological Service of Canada, brought silver-disk pyrheliometer S. I. 14 from the University of Toronto to Washington for recalibration. In spite of adverse weather conditions, satisfactory comparisons were made, indicating relatively little change in its constant since the last calibration in 1937.

(*b*) One of three modified Ångström pyrheliometers, purchased in 1951 from the Astrophysical Observatory by the Meteorological Service of the Belgian Congo, was accidentally injured in use. It was returned to us by air in May, rebuilt with new manganin strips and new thermoelements by instrumentmaker J. H. Harrison, recalibrated partly by Mr. Harrison and Mr. Aldrich in Washington and partly in the better skies of Table Mountain, Calif., and finally returned by air to the Belgian Congo.

(*c*) With the help of T. H. MacDonald and Norman Foster of the U. S. Weather Bureau, calibrations were made of a Weather Bureau normal-incidence Eppley pyrheliometer against our substandard pyrheliometer. In addition, the Weather Bureau staff was interested in attempting to transform their silver-disk pyrheliometer S. I. 78 into an automatically recording instrument. Mr. Harrison of our staff inserted a copper-constantan thermoelement attached to the back of the silver disk of S. I. 78. Mr. Foster devised an automatic shutter

which quickly opened and closed the shutter precisely on the desired seconds. The thermoelement leads were fed through an amplifier to a Leeds and Northrup micromax recorder. Several sets of comparisons were made between the automatic recorder and a silver-disk instrument read as usual. These preliminary readings looked very promising and it is hoped in the near future to make further comparisons to determine the relative accuracy of this, the first automatically recording silver-disk pyrheliometer.

Work in the field.—At Montezuma, Chile, a change in personnel occurred in June 1954. John A. Pora, for five years assistant observer at this station, returned to Washington. Dr. James E. Zimmerman of our Table Mountain (Calif.) staff replaced him at Montezuma. Mr. Pora after an extended leave will proceed to Table Mountain.

The Coast and Geodetic Survey has assigned a new seconds-pendulum precision clock to the Montezuma station, for use in the seismographic work referred to in last year's report.

At Table Mountain several special projects mentioned in previous reports have continued in operation. Further tests with the Harvard photometer and the filter pyranometer were made. The ozone studies, sponsored by Dr. Oliver R. Wulf, were materially aided by Dr. Zimmerman of our staff. This work is described in a paper by Drs. Wulf and Zimmerman entitled "A Method for the Measurement of Atmospheric Ozone Using the Absorption of Ozone in the Visible Spectrum," soon to be issued as vol. 123, No. 3, of the Smithsonian Miscellaneous Collections (Publication 4177).

In 1952 Mr. Hoover and Mr. Froiland mounted the standard water-flow pyrheliometer at Table Mountain and made a long series of comparisons against silver-disk pyrheliometer S. I. 5. The standard instrument was then dismantled and returned to Washington. To settle an uncertainty which has arisen in discussing pyrheliometers with Dr. Abbot, it seemed advisable to return the standard to Table Mountain and have Mr. Froiland remount it as it was in 1952. The uncertainty concerned the magnitude of the error due to outgoing radiation to space emitted through the aperture of the pyrheliometer and also due to brightness of the sky around the sun visible through the aperture. Before shipping the instrument, Mr. Harrison built a plastic airtight box around the thermojunctions of the water-flow pyrheliometer to reduce drift due to convection currents. As the result of Mr. Froiland's tests it is concluded that in clear skies the resulting error is negligible.

DIVISION OF RADIATION AND ORGANISMS

(Report prepared by R. B. Withrow, chief of the division)

The form assumed by higher green plants under favorable conditions is determined by heredity and the complex of environmental fac-

tors. Of the latter, light is one of the most important and determines both the rate of growth and the ultimate form that the plant assumes. The light factor exhibits its influence through various types of photochemical reactions. One of these is photomorphogenesis, the process by which light exerts its formative effect on higher green plants. In the absence of light but with adequate food reserves, the young plant fails to develop normal leaves and stems. The leaves are usually very small or rudimentary and the first formed stem nodes are much elongated. At germination, most dicotyledonous seedlings such as bean, tomato, and many others have an apical stem hook which disappears on exposure to weak light. In darkness, this hook never completely disappears. These formative effects are brought about by several photoreactions which are activated chiefly by the red end of the visible spectrum. The blue and green portions are relatively ineffective.

This division has found that the apical stem hook is an excellent and reproducible test object for measuring the effect of various radiant-energy and chemical factors on the photomorphogenic response. If the hook is removed from the plant and placed in a petri dish on moist filter paper in complete darkness, it does not open for the first 20 to 24 hours at 25° C. In the presence of very low energies of red light, however, the hook begins to open within a few hours. The rate of opening in degrees of angle is directly proportional to the logarithm of the incident radiant energy.

We have reported previously that the opening of the stem hook of 6-day old Black Valentine beans is due to a differential growth reaction which can be mediated by the native auxin, indoleacetic acid (IAA) which tends to inhibit the effect of the photoreaction. The antiauxin, triiodobenzoic acid (TIBA), which opposes the effect of auxin in many other plant responses, produces an effect similar to that of the photoreaction. It causes the hook to open partially in complete darkness, although it does not appear to be able to reproduce completely the effect of the photoreaction. Studies are now in progress to determine the kinetical relationships between auxin concentrations and red irradiance.

Histological studies of sections from dark-treated bean hooks show that the hooking is caused by the retarded growth of a group of cells on the inside of the hook which are about 60 percent shorter than those on the outside. When the hooks are irradiated with red energy, these cells increase very rapidly in length, while those on the outside elongate relatively slowly. This differential growth causes the hook to disappear and the stem to straigthen.

The effect of the red energy on initiating the early opening of the bean hook can be inhibited by a short exposure to far-red energy beyond 700 mμ. If the excised hooks are exposed to approximately 10 millijoules of red energy (625 to 700 mμ) and then placed in complete

darkness for 20 hours, the hook will open about 20°; if the red exposure is followed by far-red energy in the range of 710 to 1,000 mμ of approximately 100 millijoules, the red effect is almost completely neutralized. The photoreversal can be repeated several times on the same section and the ultimate response is determined by the wavelengths of the last given exposure. This work is being greatly expanded to determine quantitatively the relative energies required and the action spectrum of the photoreversal process.

Studies have been completed on the effectiveness of various wavelengths of the spectrum on the opening of the bean hook, using a series of interference filter monochromator units, the design of which was reported previously. With 10 of these units set up in a constant-temperature room, it has been possible to cover the spectrum from 365 to 800 mμ at intervals of 10 to 20 mμ. The action spectrum has a strong maximum at 660 plus or minus 5 mμ and evidence of two weak maxima at 620 and 700 mμ. There are no strong maxima in the blue or green. Work is now in progress on the isolation of a pigment with absorption maxima in the general regions indicated by the action spectrum. Thus far no success has been obtained in isolating such a pigment.

Excised bean hooks have been exposed to X-ray dosages ranging from 500 to 8,000 roentgens. Dosages up to 2,000 r produce an opening of the dark-grown hooks which is proportional to dosage and which is, in effect, very similar to that produced by red light. Beyond 4,000 r, increases in dosage produce a slight decrease in response. If the hooks are treated with weak red light after X-radiation there is a marked inhibition of the effect of the red energy if the X-ray dosage is more than 4,000 r, but a stimulation of the red reaction occurs with a dosage up to 2,000 r. Apparently, X-ray dosages below 1,000 r produce the same type of growth reaction as weak red light. It is not known as yet whether the two are participating in the same basic biochemical system.

Studies on the effect of auxins on respiratory processes in relationship to mitochondrial activity have not to date shown any effect of indoleacetic acid, or 2,4-dichlorophenoxyacetic acid or its ammonium salt, on the uncoupling of oxidative phosphorylation in bean plants or rat livers. Active plant mitochondrial preparations have been secured from dark-grown Black Valentine bean plants germinated in gravel culture for 3 to 4 days at 25° C., using the apical stem hook sections to prepare the homogenate.

Respectfully submitted.

L. B. Aldrich, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the National Collection of Fine Arts

SIR: I have the honor to submit the following report on the activities of the National Collection of Fine Arts for the fiscal year ended June 30, 1954:

SMITHSONIAN ART COMMISSION

The 31st annual meeting of the Smithsonian Art Commission was held in the Regents Room of the Smithsonian Building on Tuesday, December 1, 1953. Members present were: Paul Manship, chairman; Leonard Carmichael, secretary (member, ex officio); Robert Woods Bliss, Gilmore Clarke, Lloyd Goodrich, Walker Hancock, Archibald Wenley, Lawrence Grant White, Andrew Wyeth, and Mahonri Young. Thomas M. Beggs, director, National Collection of Fine Arts, was also present.

Resolutions on the deaths of James Earle Fraser, John Taylor Arms, and Frank Jewett Mather were submitted and adopted.

The Commission recommended to the Board of Regents the name of Reginald Marsh to succeed Mr. Arms and Charles H. Sawyer to replace Eugene E. Speicher. The Commission also recommended the reelection of Robert Woods Bliss, John Nicholas Brown, George Hewitt Myers, and Mahonri M. Young for the next 4-year period.

The following officers were elected for the ensuing year: Paul Manship, chairman; Robert Woods Bliss, vice chairman; and Leonard Carmichael, secretary.

The following were elected members of the executive committee for the ensuing year: David E. Finley, chairman, Robert Woods Bliss, Gilmore D. Clarke, and George Hewitt Myers. Paul Manship, as chairman of the Commission, and Leonard Carmichael, as secretary of the Commission, are ex-officio members of the executive committee.

Doctor Carmichael reported briefly on a bill (H. R. 5397), introduced by Representative Howell, "to provide for the establishment of a National War Memorial Arts Commission," and on how it might affect the National Collection of Fine Arts.

The following objects were accepted by the Commission for the National Collection of Fine Arts:

Oil, Major General George B. McClellan (1826–85), by Julian Scott, A. N. A. (1846–1901). Bequest of Georgiana L. McClellan. Accepted for the National Portrait Gallery.

Oil, Lago Maggiore, c. 1867, by William Stanley Haseltine, N. A. (1835–1900). Gift of Mrs. Roger Plowden.

Oil, The Dedication of the American Roll of Honor at St. Paul's Cathedral, July 4, 1951, by Frank O. Salisbury (1874–). Gift of the British Memorial Committee to the American people. Accepted for the Smithsonian Institution with recommendation that it be assigned to the department of history, U. S. National Museum.

Oil, The Necklace, by Richard E. Miller, N. A. (1875–1943). Henry Ward Ranger bequest.

Watercolor, Rev. George Heaton, M. A., by Edward Heaton (1824–?). Gift of Mrs. H. H. Germain.

Two miniatures, watercolor on ivory, Captain Joseph Anthony, by Walter Robertson (17?–1802), and Josiah Hewes Anthony, by James Peale (1749–1831). Gift of Mr. and Mrs. Ruel P. Tolman.

Miniature, watercolor on ivory, A Country Fair, by Van Blarenberghe. Gift of Mrs. Henry DuPrè Bounetheau.

Miniature, watercolor on ivory, Unknown Woman, by an undetermined artist. Gift of Mrs. George Bullock-Willis, in memory of her mother, Mrs. James Madison Bullock (Anna Mary Garrow).

Two bronzes, Rising Sun and Descending Night, by Adolph A. Weinman, N. A. (1870–1952). Gift of Mrs. Adolph A. Weinman.

Bronze, Edward R. Baldwin, N. A. (1864–1947), by Anthony di Bona (1896–1951). Gift of Miss Charlotte Geffken. Accepted for the National Portrait Gallery.

Seven award-winning pieces from the Fourth Annual Exhibition of Ceramic Art, 1953. Gift of The Kiln Club of Washington, D. C.:

Toureen, by Peter H. Voulkos. Winner of the International Business Machines Corporation award.

Bowl, stoneware, by Alexander Giampietro. Winner of the Frank A. Jelleff award.

Bottle, stoneware with black sand glaze, by Gordon C. Lawson. Winner of the B. F. Drakenfield award.

Bowl, brush design, by Audrey C. Hayden. Winner of the George F. Muth award.

Vase, red-brown glaze, by Vally Possony. Winner of the Popular Ceramics award.

Bowl, reduction glaze, by Marion Beachem. Winner of the Arts and Crafts award.

Bowl, stoneware with mottled glaze, by Ralph R. Fast. Winner of the Harper Electric Furnace award.

THE CATHERINE WALDEN MYER FUND

Fourteen miniatures, watercolor on ivory, were acquired from the fund established through the bequest of the late Catherine Walden Myer, as follows:

87. Peter Van Dyke (1807–52), by Mrs. J. Bogardus (1804–78).

88. Mrs. Peter Van Dyke, by Mrs. J. Bogardus.

89. Dr. Cook, by Washington Blanchard (fl. 1831–43).

90. Member of the Mayfield Family, attributed to Benjamin Trott (c. 1770–c. 1841).

91. Mr. Drury, by Thomas E. Barratt (fl. 1837–54).

92. Unidentified Gentleman, by Nathaniel Rogers (1788–1844); from S. R. McCulloch, Kirkwood, Mo.

93. George Rundle, by John Smart, Jr. (1740/1–1811); from Edmund Bury, Philadelphia, Pa.

94. Mrs. Gillis' great-great-grandmother, attributed to Raphaelle Peale (1774–1825), and

95. Mrs. Gillis' great-great-grandfather, attributed to Raphaelle Peale (1774–1825); from Mrs. Lillian Duncan Gillis, Washington, D. C.

96. Man with Red Hair, by Alvan Clark (1804–87).

97. Unknown Gentleman, by Sarah Goodridge (1788–1853).

98. Unknown Young Lady, attributed to Henry Inman (1801–46).

99. J. B., by Raphaelle Peale (1774–1825).

100. Unknown Lady, by John Ramage (1748–1802).

Nos. 87 through 91, and 96 through 100 were acquired from Mr. and Mrs. Ruel P. Tolman.

LOANS ACCEPTED

Six oils, by Edmund C. Tarbell, N. A. (1862–1938): Mr. Frick and Daughter Helen; In the Orchard; Mary Reading; Mrs. Tarbell as a Girl; Roses in Blue Vase; and a Self Portrait, were lent by Mrs. Josephine Tarbell Ferrell on July 16, 1953.

A carved-ivory writing tablet, in leather case, was lent by the Misses Hollerith on February 1, 1954.

Thirteen pieces of modern glass (2 Finnish, 5 French, 3 Swedish, and 3 American) were lent by Mr. and Mrs. Hugh J. Smith, Jr., on September 20, 1953, and one piece of Swedish glass was lent by Mr. Smith on April 12, 1954.

Five pieces of modern glass, designed and produced by Frederick Carder, were lent by him on June 28, 1954.

WITHDRAWALS BY OWNERS

Oil, The Nativity, attributed to Otto van Veen, lent by Dr. Anton Gloetzner in 1910, was withdrawn by his son, Alwin A. Gloetzner, on October 23, 1953.

Oil, Portrait of a Dutch Lady, by Michel Janszoon van Miereveld, lent in 1931 by the estate of Henry Cleveland Perkins, was withdrawn by the owner, Mrs. Mabel Ruggles, on April 6, 1954.

Nine pieces of modern glass (1 Finnish, 4 French, and 4 Swedish) were withdrawn by Hugh J. Smith, Jr., on March 24, 1954, and seven pieces (2 American, 1 French, and 4 Swedish) were withdrawn on April 12, 1954.

A pastel portrait of George Washington and a matching pastel portrait of Martha Washington, by James Sharples, were withdrawn with the consent of the owners for showing at the Washington All Society Auction on April 22, 1954, and were returned on April 30, 1954.

ART WORKS LENT

The following art works were lent for varying periods:

To the Department of State, Washington, D. C.:

July 13, 1953—Plymouth Hills, by John Wesley Beatty.
Stable Interior, Horses and Groom, by John F. Herring.
Birch Clad Hills, by Ben Foster.
(Two oils, by Edwin Scott, from the Smithsonian Lending Collection.)

July 27, 1953—Left arm and gauntlet of suit of armor, for photographing. (Returned July 31, 1953.)

October 28, 1953—The Continentals, by Frank Blackwell Mayer.

November 10, 1953—Early Spring, by Alexander Theobald Van Laer.
The Path to the Village, by John Francis Murphy.
(One oil, by Edwin Scott, from the Smithsonian Lending Collection.)

February 9, 1954—Moonrise, by Ralph A. Blakelock.
Sunset, Navarro Ridge, California Coast, by Ralph Blakelock.
September Afternoon, by George Inness.
Lago Maggiore, by William Stanley Haseltine.

To the Supreme Court, Washington, D. C.:

December 8, 1953—A family of Birches, by Willard L. Metcalf. (Returned February 2, 1954.)
A Group of Elk, Wind River Mountains, Wyoming, by Edwin W. Deming.
Marine Study, by Franklin D. Briscoe.

February 2, 1954—Tohikon, by Daniel Garber.

To the U. S. Court of Military Appeals, Washington, D. C.:

July 22, 1953—Night Attack on the Gen. Armstrong, Off Pico, Azores, by William E. Norton.
Westward the Course of Empire Takes Its Way, by Emanuel Leutze. (Returned April 15, 1954.)

April 15, 1954—Laguna, New Mexico, by Albert L. Groll.

To the American Institute of Architects, Washington, D. C.:

August 21, 1953—Table, French, 18th century (P. 220).

October 1, 1953—Model of prize-winning design for the Smithsonian Gallery of Art, by Eliel Saarinen.

To the United States Information Agency, to be included in the traveling exhibition of American Drawings:

December 18, 1953—The Devil's Tower from Johnston's, Crook County, Wyoming, by Thomas Moran.

To the Bureau of the Budget, Washington, D. C.:

September 18, 1953—Young Girl With Dog, by Edward P. Moran.
(One oil, by Edwin Scott, and two pastels by Alice Pike Barney, from the Smithsonian Lending Collection.)

To Dickinson College, Carlisle, Pa., for a special exhibition of portraits by George P. A. Healy, November 12 through 24, 1953 (shipped November 6, 1953, and returned December 4, 1953):

Col. Albert G. Brackett.
Mrs. Joseph B. Collins.
Gen. Albert J. Myer.
Mrs. Albert J. Myer.
William G. Preston.
Vinnie Ream (Mrs. Hoxie).
Gen. William T. Sherman.
Mrs. William T. Sherman.
Self Portrait.

To The Century Association, New York City, for a retrospective exhibition of the work of John C. Johansen, December 2, 1953, through January 10, 1954 (shipped November 24, 1953, and returned January 18, 1954):

Hon. Earl of Balfour (sketch).
Marshal Earl Haig (sketch and oil).
Marechal Joseph Joffre (sketch and oil).
Premier Ignace Jan Paderewski (sketch).

To the Detroit Institute of Arts for a special exhibition January 19 through February 28, 1954 (shipped January 6 and returned March 18, 1954):

Chelsea Vase (P. 877).

To the Joslyn Art Museum, Omaha, Nebr., for an Omaha Centennial exhibition, "Life on the Prairie, The Artist's Record," May 12 through July 4, 1954 (shipped April 16, 1954):

Fired On, by Frederic Remington.
Westward the Course of Empire Takes Its Way, by Emanuel Leutze.

To the Institute of Contemporary Arts, Boston, Mass., for a special exhibition of the artist's work, May 19 through June 30, 1954 (shipped May 5, 1954):

Prince Kimmochi Saionji, by Charles Hopkinson.

To the Department of Agriculture, Division of Entomology, for a special exhibition during the month of June (returned June 30, 1954):

Five pieces of 18th-century porcelain from the Pell collection showing insects as decorations.

LOANS RETURNED

Oil, Laguna, New Mexico, by Albert Lorey Groll, lent February 6, 1953, to the White House, was returned April 15, 1954.

Two oils, Cliffs of the Upper Colorado River, Wyoming Territory, by Thomas Moran, and Moonlight, by Albert P. Ryder, lent January 12, 1953, to the American Federation of Arts for an exhibition of 19th-Century American Paintings to be circulated in Germany, were returned June 2, 1954.

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SMITHSONIAN LENDING COLLECTION

One watercolor, The Placid Potomac, by William H. Holmes (1846–1933), the gift of Mrs. George F. Becker, was added to the collection.

One pastel, Portrait of Ali Kuli Khan, lent to the United States District Court for the District of Columbia on February 18, 1953, was withdrawn and returned to the owner, Ali Kuli Khan, on February 17, 1954.

Three paintings by Edwin Scott were lent to the Department of State: The Cabs and St. Gervais, on July 13, 1953, and The Madeleine, on November 10, 1953.

Two paintings were lent to the United States District Court for the District of Columbia: R. D. Shepherd as Shylock, by Alice Pike Barney, on July 28, 1953, and Ernest Lee Major, by S. Burtis Baker, on September 23, 1953.

Three paintings were lent to the Bureau of the Budget: L'Heure Bleu a Paris, by Edwin Scott, and Village Street and Bar Harbor, by Alice Pike Barney, on September 18, 1953.

Ten paintings by Edwin Scott were lent to the Department of Health, Education, and Welfare, on January 18, 1954: La Concorde; Marine; Place de la Concorde No. 2; Porte Saint Martin No. 1; Rue de Village; Rue des Pyramides; Rue San Jacques, Paris; St. Germain des Pres No. 1; The Seine at Paris, Pont de la Concorde; and Self Portrait.

ALICE PIKE BARNEY MEMORIAL FUND

An addition of $5,000 to the fund established in 1951 by Miss Natalie Clifford Barney and Mrs. Laura Dreyfus-Barney, in memory of their mother, for the purpose of encouraging the appreciation and creation of art in the United States, was received in January 1954.

THE HENRY WARD RANGER FUND

According to a provision in the Ranger bequest that paintings purchased by the Council of the National Academy of Design from the fund provided by the Henry Ward Ranger bequest and assigned to American art institutions may be claimed during the 5-year period beginning 10 years after the death of the artist represented, one painting "The Necklace," by Richard E. Miller, N. A., was recalled and accepted by the Smithsonian Art Commission at its meeting on December 1, 1953.

The following paintings, purchased by the Council of the National Academy of Design since the last report, have been assigned as follows:

Title and Artist	*Assignment*
143. Alienation of the Fathoms (watercolor), by Kenneth Nack (1923–).	University of Nebraska, Lincoln, Nebr.
144. Facade (watercolor), by James W. Parr (1923–).	Detroit Institute of Art, Detroit, Mich.
145. Black and White, by Alexander Brook, N. A. (1898–).	Roswell Museum, Roswell, N. Mex.
146. March, Vermont, by Emil A. Gruppe (1896–).	Fort Wayne Art School and Museum, Fort Wayne, Ind.
147. Abandoned, by George Picken (1898–).	University of Texas, Austin, Tex.
148. Bahnhof, by Eric J. Ryan, Jr. (1930–).	Smith College, Northhampton, Mass.
149. Sea Life (watercolor), by Irene Saasto-Aunio (1919–).	Evansville Public Museum, Society of Arts, History and Science, Evansville, Ind.
150. End of Winter (watercolor), by A. Lassell Ripley (1896–).	(Not yet assigned.)
151. Tower Bridge (watercolor), by Donald Teague, N. A. (1897–).	Virginia Museum of Fine Arts, Richmond, Va.
152. Bridge at Booth Bay (watercolor), by Edmond J. Fitzgerald (1912–).	Bedford Carnegie Library, Bedford, Ind.
153. Back Country (watercolor), by Henry C. Pitz, N. A. (1895–).	Cleveland Museum of Art, Cleveland, Ohio.
154. Serviceman's Wife, by Ivan G. Olinsky, N. A. (1878–).	Birmingham Museum of Art, Birmingham, Ala.
155. The Shadow, by John Carroll, N. A. (1892–).	University of Arizona, Tucson, Ariz.
156. Carrousel Bridge, Paris, by Edwin Dickinson, N. A. (1891–).	Bowdoin College, Museum of Fine Arts, Brunswick, Maine.
157. The Outer Reefs, by Paul Wescott (1904–).	Albany Institute of History and Art, Albany, N. Y.
158. Ruins Along the Schuylkill, by Francis Speight, N. A. (1896–).	Rochester Memorial Art Gallery, University of Rochester, Rochester, N. Y.
159. City Streets (watercolor), by Herb Olson, A. N. A. (1905–).	Cayuga Museum of History and Art, Auburn, N. Y.
160. Autumn Fields (watercolor), by Tore Asplund, N. A. (1903–).	Asheville Art Museum, Asheville, N. C.
161. Morning Light, by Robert Nisbet, N. A. (1879–).	Wesleyan College, Macon, Ga.
162. Industrial Landscape, by Thomas Yerxa (1923–).	University of Pennsylvania, Wharton School of Finance and Commerce, Philadelphia, Pa.

SMITHSONIAN TRAVELING EXHIBITION SERVICE

Fifty-one exhibitions were circulated during the past season, 46 in the United States and Canada, and 5 abroad, as follows:

UNITED STATES AND CANADA

Painting and Drawing

Title	*Source*
American Natural Painters	Galerie St. Etienne and private collectors.
Children's Paintings from Forty-five Countries, I.	Embassy of Denmark; Friendship Among Children and Youth Organization.
Children's Paintings from Forty-five Countries, II.	
Children's Paintings from Forty-five Countries, III.	
Children's Paintings from Japan	United Nations Educational, Scientific, and Cultural Organization.
Chinese Paintings by Tseng Yu-ho	Art Institute of Chicago; artist.
Contemporary American Drawings	American Academy of Arts and Letters; artists.
Fuseli Drawings	Pro Helvetia Foundation in Zurich; Legation of Switzerland.
German Drawings and Watercolors	Dr. Charlotte Weidler.
Gloriana	British Embassy; artist, John Piper.
Paintings by Austrian Children	Superintendent of Schools in Vienna; Embassy of Austria.
Seven Cuban Painters	Institute of Contemporary Art in Boston; Pan American Union.
Watercolors and Drawings by Gavarni.	Walters Art Gallery, Baltimore; Rosenwald Collection, National Gallery of Art.
Winslow Homer Drawings	Cooper Union Museum; American Academy of Arts and Letters.

Graphic Arts

American Color Prints	Library of Congress.
Children's Books from Fifty Countries.	U. S. Office of Education and State Department.
Children's Picture Books, I	Washington Post Children's Book Fair.
Children's Picture Books, II	
Modern Swedish Bookbinding	Swedish Association of Master Bookbinders; Embassy of Sweden.
Prints, 1942–1952	Brooks Memorial Art Gallery; artists.
Woodcuts by Antonio Frasconi	The Print Club of Cleveland; The Cleveland Museum of Art; Weyhe Gallery; artist.

Architecture

New Libraries	American Institute of Architects.
The Re-union of Architecture and Engineering.	American Institute of Architects.
The Crystal Palace	Smith College Museum of Art; Massachusetts Institute of Technology.

Textiles

Title	*Source*
Swedish Textiles	Swedish Homecraft League; Friends of Textile Art; Embassy of Sweden.

Design

American Craftsmen	University of Illinois, Urbana.
Brazilian Landscape Architecture—New Designs by Roberto Burle Marx.	Brazilian Embassy; artist.
Design from Britain	Council of Industrial Design; British Embassy.
Furniture, Costume, and Textiles	Index of American Design, National Gallery of Art.
Textiles and Ceramics	Museum of Cranbrook Academy of Art; artists.

Photography

Birds in Color, by Eliot Porter	Artist.
Twenty-five Years on Ice	Dr. Bradford Washburn.

Ceramics

Artists and Potters of Vallauris, I	René Batigne, Director, Museum of Vallauris, France.
Artists and Potters of Vallauris, II	
German Ceramics	Professor G. von Pechmann, Director of the Museum for Applied Arts in Munich; The Diplomatic Mission of the Federal Republic of Germany.

Folk Art

Americana	Index of American Design, National Gallery of Art.
Eskimo Art, I	Eskimo Art, Inc.; Canadian Handicrafts Guild.
Eskimo Art, II	
Norwegian Decorative Painting	Norwegian Artists Guild; Embassy of Norway.
Our Wide Land	Index of American Design, National Gallery of Art.
Pennsylvania German Arts and Crafts.	Index of American Design, National Gallery of Art.
Popular Art in the United States	Index of American Design, National Gallery of Art.
The Art of the Spanish Southwest	Index of American Design, National Gallery of Art.

Oriental Art

Chinese Gold and Silver—from the Kempe Collection.	Dr. Carl Kempe; Embassy of Sweden.

Ethnology

Art and Magic of Arnhem Land	Smithsonian Institution, Department of Anthropology.
Carl Bodmer Paints the Indian Frontier.	Karl Viktor Prinz zu Wied; The Diplomatic Mission of the Federal Republic of Germany.

ABROAD

American Drawings.
Fine American Printing.
High-Speed Photography.
Beyond the Mississippi with George Catlin.
The Story of American Glass.

These displays were scheduled as an integral part of the program of the United States Information Agency and 121 museums and galleries located in 36 States, the District of Columbia and Canada. Special catalogs were published for each of the following important exhibitions: Fuseli Drawings; Watercolors and Drawings by Gavarni; Carl Bodmer Paints the Indian Frontier; and Chinese Gold and Silver in the Carl Kempe Collection (published in Sweden by the owner and lender, Dr. Carl Kempe). Special acknowledgments for the Fuseli and Bodmer catalogs were written by Mrs. Annemarie H. Pope, chief of the Smithsonian Traveling Exhibition Service.

INFORMATION SERVICE AND STAFF ACTIVITIES

In addition to the many requests for information received by mail and telephone, inquiries made in person at the office numbered 2,122. Examination was made of 748 works of art submitted for identification.

The staff members of the National Collection of Fine Arts served on juries for 8 exhibitions, delivered 5 lectures (4 illustrated), participated in 1 radio broadcast, and made 1 TV appearance.

An article, "National Collection of Fine Arts, John Gellatly (1853–1931)," by Thomas M. Beggs, was printed in the summer, 1954, issue of the American Society Legion of Honor Magazine, and one by Paul V. Gardner, curator of ceramics, "Archaeological Highlights in the John Gellatly Collection," was published in the summer, 1954, issue of Archaeology.

Rowland Lyon, exhibits preparator, held three special exhibitions: 35 prints at the Division of Graphic Arts, United States National Museum, during December 1953; 49 oils, watercolors, prints, and sculptures, at George Washington University in May 1954; and 25 block prints at the Galleria Clan, Madrid, Spain, during June 1954.

REPAIRS AND IMPROVEMENTS TO THE COLLECTION

In continuance of the cleaning, revarnishing, and replacing in renovated frames or mounts, with the aid of the Museum's maintenance and repair staff, of 1,730 paintings, sculptures, and other objects, during the reorganization of the permanent exhibition in 1952–53, the following work was done during the past year:

Seventy-two paintings and sculptures were cleaned, or revarnished, or otherwise renovated, for use on permanent exhibition or as loans.

Two hundred and twenty-nine paintings were removed from storage, inspected, and hung on screens in a reequipped and repainted air-conditioned room.

A Chinese bronze buckle (269 Gellatly Collection) was renovated by Joseph Ternbach in September 1953.

Ruins and Figures, by Guardi, and two portraits of Mr. and Mrs. Joshua Johnson, formerly attributed to Trumbull, were X-rayed by the National Gallery of Art on November 18, 1953.

The work of repairing the Turfan frescoes in the Gellatly Collection was undertaken by Doanda Wheeler on June 18, 1954.

In June 1954 Neshan G. Hintlian began renovation of the tapestry "Julius Caesar Crossing the Rubicon."

SPECIAL EXHIBITIONS

Twelve special exhibitions were held during the year:

September 4 through 27, 1953.—The Fourth Annual International Exhibition of Ceramic Arts, sponsored by the Kiln Club of Washington, consisting of 211 pieces (77 by local ceramic artists; 17 by local and invited artists in stained glass; 64 by invited American artists, and 53 by artists of various nations through their respective Embassies or Legations in Washington). Demonstrations on the potter's wheel were given three times daily. A catalog was privately printed.

October 9 through 29, 1953.—"Beyond the Mississippi with George Catlin," consisting of 27 oil paintings of American Indians and views of the western United States, done by George Catlin between 1832 and 1836, and a portrait of George Catlin, by William Fisk. The Catlin paintings, lent by the Department of Anthropology of the United States National Museum, were assembled for the Smithsonian Traveling Exhibition Service and were sent to Europe under the sponsorship of the United States Information Agency. A mimeographed catalog was provided.

October 21 through November 29, 1953.—Exhibition of an oil painting, "The Dedication of the American Roll of Honor at St. Paul's Cathedral, July 4, 1951," by Frank O. Salisbury, presented to the American Nation on behalf of the British Memorial Committee, by Sir Roger Makins, Ambassador from Great Britain to the United States, and accepted for the American People by Adm. Arthur W. Radford, U.S.N., Chairman of the Joint Chiefs of Staff.

November 8 through 29, 1953.—The Sixteenth Metropolitan State Art Contest, held under the auspicies of the D. C. Chapter, American Artists Professional League, assisted by the Entre Nous Club, consisting of 299 paintings, sculpture, prints, ceramics, and metalcraft. A catalog was privately printed.

December 6, 1953, through January 3, 1954.—An exhibition of Children's Art from Division 1 of the Public Schools of Washington, D. C., consisting of about 300 oil paintings; watercolors; sculptures in wood, ceramics, plaster, and wire; mobiles; block-printed textiles; graphic arts; puppets; masks; examples of lettering; and publications.

January 10 through 27, 1954.—An archeological exhibition, "From the Land of the Bible," assembled by the American Fund for Israel Institutions from museums and private collections all over the world, consisting of about 591 items. A catalog was privately printed.

February 5 through 26, 1954.—The Sixty-second Annual Exhibition of the

Society of Washington Artists, consisting of 108 paintings and 26 pieces of sculpture. A catalog was privately printed.

March 7 through 28, 1954.—The Fifty-seventh Annual Exhibition of the Washington Water Color Club, consisting of 164 watercolors, etchings, and drawings. A catalog was privately printed.

April 11 through 29, 1954.—The Biennial Art Exhibition of the National League of American Pen Women, consisting of 248 paintings, sculpture, prints, ceramics, and metalcraft. A catalog was privately printed.

May 9 through 31, 1954.—The Twenty-first Annual Exhibition of the Miniature Painters, Sculptors, and Gravers Society of Washington, D. C., consisting of 235 examples. A catalog was privately printed.

May 9 through 31, 1954.—An exhibition of Dolls and Related Objects, by the Dollology Club of Washington, consisting of 900 items. A catalog was privately printed.

June 15 through July 11, 1954.—A Loan Exhibition of Paintings, by Per Krohg, under the patronage of His Excellency, the Ambassador from Norway, Mr. Wilhelm Munthe de Morganstierne, consisting of 42 paintings. A catalog was privately printed.

Respectfully submitted.

THOMAS M. BEGGS, *Director.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Freer Gallery of Art

SIR: I have the honor to submit the Thirty-fourth Annual Report on the Freer Gallery of Art for the year ended June 30, 1954.

THE COLLECTIONS

Thirty-eight objects were added to the collections by purchase as follows:

BRONZE

53.80, 53.81. Chinese, Late Chou dynasty (4th-3d century B. C.). Pair of cast-bronze finials; design inlaid with gold and silver; some earthy incrustations and green patina. 0.040 x 0.061.

53.82. Chinese, Late Chou dynasty (4th-3d century B. C.). Gilt-bronze belt hook inlaid with carved and plain jade, covered here and there with green patination. 0.054 x 0.090.

53.83. Chinese, Early Chou dynasty (11th-10th century B. C.). Bronze ceremonial tripod vessel with cover, of type *chio*; decorations in intaglio and low relief; gray-colored bronze with patches of malachite and azurite. Inscription of 16 characters inside opposite handle and repeated inside cover. 0.224 x 0.095. (Illustrated.)

53.88. Chinese, Late Chou dynasty (4th-3d century B. C.). Gilt-bronze openwork belt hook; designs inlaid with turquoise. Length: 0.245.

54.13. Chinese, Shang dynasty (12th-11th century B. C.). Vessel of the type *fang i*; smooth gray to green patina; decorations cast in low relief and intaglio. Inscription of one character inside body near lip. 0.191 x 0.107 x 0.077.

54.14. Chinese, Han dynasty (207 B. C.–A. D. 220). Cast-bronze fitting, green patina. 0.150 x 0.040.

54.15. Chinese, Shang dynasty (12th-11th century B. C.). Ceremonial vessel of the type *chüeh*; decorations cast in relief and intaglio; gray-green patina with flecks of cuprite; four-character inscription under handle. 0.232 x 0.187 x 0.103.

JADE

54.7. Chinese, Late Chou dynasty (4th-3d century B. C.). Ornament; nephrite, white to mottled shades of brown. 0.057 x 0.050.

METALWORK

53.92 Perslan, 3d to 7th century A. D., Sasanian period. Bottle stand consisting of a ring held up by four pairs of uprights fixed to a wide flat base, each pair framing a standing eagle. Broken and put together. 0.085 x 0.178.

53.89. Syrian, 14th century, Mamluk period. Plate, inlaid with silver and gold to form designs of birds and other animals and inscriptions in circular bands. Some of the silvery inlay and nearly all the gold has fallen out. 0.032 x 0.289.

PAINTING

53.91. Arabic (Mesopotamian), A. D. 1224 (Rajab 621 H.), Baghdad School, written by 'Abdallāh ibn al-Faḍl. Outdoor scene with mad dog biting man, onlooker with sword on left. An illustration on the recto of a leaf from an Arabic translation of the *Materia Medica* by Dioscorides. Opaque color and gold. Text in black *naskhī* on both sides. Captions on verso in red. 0.332 x 0.250. (Illustrated.)

53.78. Chinese, Ming dynasty, by T'ang Yin (A. D. 1470–1523.). Handscroll landscape entitled *Nan Yu*. Ink on paper; signatory inscription and 10 seals on painting; 22 seals and 10 inscriptions on mount; label. 0.243 x 0.893.

53.79. Chinese, Ming dynasty, by Ch'ên Shun (A. D. 1482–1539). Handscroll landscape entitled *Yün-shan*, and dated in correspondence with A. D. 1535. Ink and color on paper; signatory inscription and 17 seals on painting; 21 seals and 2 inscriptions on mount; label. 0.305 x 1.407.

53.84. Chinese, Ming dynasty, by Ch'iu Ying (ca. A. D. 1522–1560). Landscape entitled *Sung hsia hêng ch'in t'u*, "Play the *ch'in* beneath a pine tree"; done in ink and slight color on paper; signature and 10 seals on painting; 2 colophons and 8 seals on mount; 1 seal on label. 1.053 x 0.222.

53.85. Chinese, Yüan dynasty, by Wu Chên (A. D. 1280–1354). Bamboo; dated in correspondence with June 17, 1350; ink on paper; signatory inscription and 7 seals on painting; 2 inscriptions and 7 seals on mount; 1 seal on label. 1.090 x 0.326.

54.8 Chinese, Ming dynasty, by Hsü Wei (A. D. 1520–1593). Twelve flowers and poems; painted in ink on paper; 42 seals on painting and 12 on mount; 12 inscriptions on painting and 1 on mount; label on outside mounting. 5.355 x 0.325.

54.10. Chinese, Yüan dynasty, attributed to Ch'ien Hsüan (13th century). A branch of pear blossoms painted in color on paper. One seal on painting. 0.315 x 0.397.

54.12. Chinese, Yüan dynasty, by Shêng Mou (14th century A. D.). Awaiting the Ferry at Autumn River, dated in correspondence with April 12, 1351. Landscape in ink on paper; signature and 6 inscriptions on painting; 31 seals on painting; title label with 2 seals on outside mount. 1.125 x 0.465.

54.17. Chinese, Ming dynasty, by Hsieh Shih-ch'ên (A. D. 1488–1548). Landscape in ink on silk, signature and one seal on painting; inscription and one seal on label. 1.081 x 0.481.

54.1. Egyptian, ca. 1335. Page from Bidpai's *Fables*. Recto: 13 lines of black *naskhī* script. Verso: color on gold ground showing a man, saddled horse and boar. Blue frame. Three lines of text in *naskhī* below, additional words in margin. 0.249 x 0.176.

54.2. Egyptian, ca. 1335. Page from Bidpai's *Fables*. Recto: 13 lines of black *naskhī* script. Verso: color on gold ground showing a bear on the ground conversing with two monkeys in a tree. Blue frame. One line of text in *naskhī* above and two below. 0.249 x 0.176.

53.93. Indian, early 17th century, Mughal, School of Jahāngīr (1605–1627), attributed to Muhammad 'Alī. Verso of an album sheet with miniature of a youth in a stylized landscape. He is seated on a low, golden stool and reading a book; a falcon is perched on a stand before him. Attribution in black *nashkī* on mount. Wide border with realistically rendered flowers. Opaque color and gold on paper, mounted on cardboard. Recto blank. 0.333 x 0.210.

54.6. Indian, Mughal, School of Akbar, about 1600. Page from an unidentified Persian prose text. Recto: 17 lines of black *nasta'liq* script. Verso: full-page miniature in gold and colors showing the worship of Lord Krishna in the Golden City, with a pastoral scene of cowherd and cattle in the foreground. 0.349 x 0.232.

53.94. Japanese, 15th century. Ashikaga School, by Sesshū. Birds and Flowers of the Four Seasons. Spring and Summer. Painted in *sumi* with color added. Signature and one seal. Pair with 53.95. 1.619 x 3.595. (Illustrated.)

53.95. Japanese, 15th century, Ashikaga School, by Sesshū. Birds and Flowers of the Four Seasons. Autumn and Winter. Painted in *sumi* with color added. Signature and one seal. Pair with 53.94. 1.619 x 3.586.

54.9. Japanese, late 14th century or early 15th century, late Kamakura or early Ashikaga Buddhist. Amida Buddha, attended by Kannon and Seishi, welcoming souls to paradise. Painted in colors and gold with *kirigane* (cut gold leaf). No signature or seal. 1.100 x 0.495.

54.11. Japanese, late 18th century, Kyoto School, by Mori Sosen (1749–1821). Three Monkeys and Wasps. Color and ink. Signature and seal. 1.097 x 0.517.

54.4. Persian, second quarter of 16th century, Safavid period, School of Shāh Ṭahmāsp, attributed to Maḥmūd Muṣawwir. Half of a double-page miniature showing one of two opposing armies. Pasted on thick paper, margin slightly stained. Color and gold on paper. 0.322 x 0.206.

54.5. Persian, second quarter of 16th century, Safavid period, School of Shāh Ṭahmāsp, attributed to Maḥmūd Muṣawwir. Half of a double-page miniature showing one of two opposing armies. Attributed on the lower (new) margin of the miniature. Pasted on thick paper, margin slightly stained. Color and gold on paper. 0.323 x 0.210.

POTTERY

53.75. Chinese, Ming dynasty, Chêng-tê period (A. D. 1506–1521). Bowl with slightly flaring rim; fine white porcelain; plain, transparent, glossy glaze; decoration in underglaze blue; inside, a border of thunder pattern and in the center an Arabic inscription surrounded by scrolls; outside, six circles with Arabic script amid floral motifs. Six-character Chêng-tê mark on base. 0.123 x 0.280.

53.76. Chinese, Ming dynasty, early 15th century. Dish with flaring rim; white porcelain; plain, transparent glaze, none on base; decoration in underglaze blue, wave border, floral scroll in cavetto, melon vine in center and six fruit sprays on outside. 0.073 x 0.377.

53.77. Chinese, Ming dynasty, early 15th century. Dish with flaring foliate rim; white porcelain; plain, transparent glaze, none on base; decoration in underglaze blue, floral scroll border and flower sprays in 12 moulded sections of the cavetto, 3 bunches of grapes on vine in center and 12 flower sprays on outside. 0.089 x 0.447.

53.90. Mesopotamian, 10th century. Vase, luster painted, with two superimposed stylized birds alternating twice with a long-robed figure with inclined head, the designs being separated by five-unit arabesque tree. Broken and put together. 0.282 x 0.232.

54.16. Persian, 10th-11th century, Nishapur type. Dish, wide flat rim, small foot; soft, buff-white clay, stained on base; opaque cream-white glaze, partly crackled and stained; decorated with a band of Kufic writing from rim to rim in brown slip except for three letters in red. One brown letter at top and bottom. Broken and repaired. 0.050 x 0.850.

54.3. Turkish (Ottoman), ca. 1500. Dish with wide flaring rim; buff-colored, fairly soft clay; thin, transparent glaze; decorated with floral designs in underglaze blue. 0.065 x 0.393.

STONE SCULPTURE

53.86, 53.87. Chinese, Six Dynasties. Pair of limestone sculptures in high relief; demon figures as bases to pilasters; from Hsiang-t'ang-shan caves; backed up and mounted in concrete. 53.86: 0.805 x 0.557; 53.87: 0.844 x 0.534.

Total number of accessions to date (including above)..... 10,832

REPAIRS TO THE COLLECTIONS

Forty-eight Chinese and Japanese objects were restored, repaired, or remounted by T. Sugiura, who also made three rubbings of inscriptions on bronzes and mounted these and 19 other rubbings made by Prof. S. Umehara. He also mounted four fragments of Japanese *sutras* for the library and repaired or remounted six Near Eastern objects in the collection. John and Richard Finlayson of Boston repaired and revarnished two American paintings, and Mr. Gettens remended a piece of Persian pottery.

CHANGES IN EXHIBITIONS

Changes in exhibitions totaled 409 as follows:

American art:	
Oil paintings	9
Arabic art:	
Glass	5
Manuscripts	2
Paintings	4
Armenian art:	
Manuscripts	6
Chinese art:	
Bronze	61
Gold	1
Lacquer	3
Paintings	23
Pottery	29
Sculpture, stone	6
East Christian art:	
Paintings	5
Egyptian art:	
Bronze	2
Crystal	3
Gold	2
Greek art:	
Manuscripts	7
Indian art:	
Paintings	7

Japanese art:	
Lacquer	13
Paintings	43
Pottery	2
Persian art:	
Manuscripts	3
Metalwork	22
Paintings	116
Pottery	24
Syro-Egyptian art:	
Metalwork	2
Pottery	3
Tibetan art:	
Paintings	2
Turkish art:	
Paintings	4

LIBRARY

Accessions of books, pamphlets, periodicals, and study materials came to a total of 655 pieces, of which over one-half were received as gifts from generous friends and institutions.

Cataloging included 662 analytics, 204 books and pamphlets, and 55 titles recataloged and reclassified. A total of 4,047 cards were added to the catalogs and shelf lists.

Three bibliographies were prepared in response to outside requests and two bibliographies were revised for publication in Freer Gallery Study Outlines. A total of 449 items were bound, labeled, repaired, or mounted. Cards were completed for the index of Chinese artists. The compilation of material for "Abstracts of Technical Studies in Art and Archaeology, 1943–1952," mentioned in the last annual report, was completed.

PUBLICATIONS

Two publications of the Gallery were issued during the year:

Revised edition of Gallery XIII Gallery Book (Chinese Art).
Revised bibliography for the Annotated Outlines of Chinese Art.

Papers by staff members appeared in outside publications as follows:

Ettinghausen, Richard: "Islamic Art" (translated into Hebrew by publisher), Encyclopaedia Hebraica, vol. 5, cols. 25–30, 5 figs. Jerusalem, 1953.

———. "Islamic Architecture" (translated into Hebrew by publisher), ibid., vol. 5, cols. 737–752, 14 figs.

———. L. A. Mayer, Mamluk Costume, Geneva, 1952, reviewed in *The Muslim World*, vol. 43, pp. 297–298, 1953.

———. A. C. Weibel, Two Thousand Years of Textiles, New York, 1952, reviewed in *U. S. Quart. Book Rev.*, vol. 9, p. 285, 1953.

Gettens, Rutherford J.: "True and False Vermillion on Early Chinese Ceramics," Far Eastern Ceramic Bull., Hui-Hsien Number, vol. 6, No. 1, Serial No. 25, March 1954.

Pope, John A.: S. Yorke Hardy, Illustrated catalogue of Tung, Ju, Kuan, Chun, Kuang-tung and Glazed I-Hsing Wares in the Percival David Foundation of Chinese Art, reviewed in the *Far Eastern Quart.*, vol. 13, No. 3, pp. 346–347. May 1954.

REPRODUCTIONS

During the year the photographic laboratory made 2,706 prints, 625 glass negatives, and 1,239 lantern slides. Total number of negatives on hand, 10,555; lantern slides, 8,187.

The Gallery engaged the services of Alva Studios of New York to make reproductions of objects in the collections. These reproductions are sold by Alva Studios and through various outlets; the Gallery buys at a discount such objects as it requires for sale through the sales desk.

BUILDING

The general condition of the Freer Building is good, and the maintenance and operation have been satisfactory. The exterior needs cleaning and pointing, and all interior areas are sorely in need of painting, decorating, lighting, air-conditioning, floor covering, etc. The continuing lack of a full-time painter is reflected in the increasing dilapidation of the interior.

The major project of the cabinet shop has been the production and installation of extensive new storage facilities in No. 1 Storage. Miscellaneous odd jobs in connection with storage, exhibition, restoration, crating, and the maintenance of office and Gallery equipment continue as usual.

Extensive replanting and soil conditioning have been carried out in the court, and all planting maintained steady growth and is in good condition.

ATTENDANCE

The Gallery was open to the public from 9 to 4:30 every day except Christmas Day; on Tuesdays the hours were 2 to 10. Public response to the Tuesday evening openings was slight, and the experiment was terminated on May 4, 1954, after a trial period of 49 weeks. The total number of visitors to come in the main entrance was 71,747. The highest monthly attendance was in April, 9,421, and the lowest was in December, 2,494.

There were 1,798 visitors to the office during the year:

For general information	745
To see staff members	132
To read in the library	179
To make sketches and tracings from library books	1
To see building and installations	46
To take photographs in court and exhibition galleries	73
To make sketches in the exhibition galleries	8
To examine, borrow, or purchase slides	24
To submit objects for examination	405

To see objects in storage:

Washington MSS	8
Far Eastern paintings and textiles	143
Near Eastern, Indian, and Armenian paintings and manuscripts	31
American paintings	14
Oriental pottery, jade, bronze, lacquer, woodcarving, bamboo, ivory, and furniture	93
All sculpture	10
Syrian and other glass	2
Near Eastern metalwork, Gold Treasure, and Byzantine objects	4

HERZFELD ARCHIVE

The Herzfeld material continues to be used by scholars in Near Eastern archeology throughout the world.

AUDITORIUM

The series of illustrated lectures on Oriental Art begun on May 26, 1953, continued to attract good audiences. The following lectures were given during the year:

1953

Oct. 20. Prof. Benjamin Rowland, Harvard University, gave an illustrated lecture on "Chinese Painting in the Ming Dynasty." Attendance, 290.

Nov. 17. Prof. Alexander Soper, Bryn Mawr College, gave an illustrated lecture on "Japanese Scroll Painting." Attendance, 184.

1954

Jan. 19. Robert Treat Paine, Jr., Museum of Fine Arts, Boston, gave an illustrated lecture on "Japanese Screen Painting." Attendance, 338.

Feb. 9. Prof. Ernst Kühnel, Director Emeritus, Islamic Department, State Museums, Berlin, Germany, gave an illustrated lecture on "Persian Miniature Painting." Attendance, 185.

Mar. 23. Prof. D. S. Rice, School of Oriental and African Studies, University of London, England, gave an illustrated lecture on "A Picture Book from Baghdad." Attendance, 151.

Apr. 20. Prof. Max Loehr, Department of Fine Arts, University of Michigan, Ann Arbor, Michigan, gave an illustrated lecture on "Ancient Chinese Bronzes." Attendance, 146.

In addition the auditorium was used for two lectures by staff members:

1953

Sept. 19. Dr. Ettinghausen addressed the Colloquium of Islamic Civilization which met in the Freer Gallery auditorium; subject, "Islamic Art." (Illustrated with color slides.) Attendance, 67.

1954

Apr. 27. Mr. Pope gave an illustrated lecture on "The History of Chinese Art" to Dr. C. Y. Hu's class from the University of Maryland, which met in the Freer Gallery auditorium. Attendance, 57.

Three outside organizations used the auditorium as follows:

1953

Oct. 27. U. S. Department of Agriculture Bureau of Agricultural Economics used the Freer Gallery auditorium from 12 noon to 4:40 p. m. for an Outlook Conference on "Housing." Attendance, 148.

Oct. 27. The Washington Society of the Archaeological Institute of America used the Freer Gallery auditorium for a lecture at 8:15 p. m. by Prof. Christopher Hawks of Oxford University on "Transformation of Classical Elements in Celtic Art." Attendance, 48.

Nov. 5. Resettlement Administration of the U. S. Department of Agriculture held a meeting in the Freer Gallery auditorium from 2 to 4:30 p. m. Attendance, 68.

STAFF ACTIVITIES

The work of the staff members has been devoted to the study of new accessions, of objects contemplated for purchase, and of objects submitted for examination, as well as to individual research projects in the fields represented by the collections of Chinese, Japanese, Persian, Arabic, and Indian materials. Reports, oral or written, and exclusive of those made by the technical laboratory on specimens (listed below), were made upon 3,781 objects as follows: belonging to private individuals, 2,304; belonging to dealers, 862; belonging to other museums, 615. In all, 1,115 photographs of objects were examined and 668 oriental language inscriptions were translated for outside individuals and institutions. By request, 13 groups totaling 223 persons met in the exhibition galleries for docent service by staff members; and 3 groups totaling 57 persons were given docent service in the study-storage rooms. There were 96 distinguished foreign visitors who studied the collections.

In the technical laboratory 85 objects from the Freer Collection were examined and 49 from outside sources. The project on organic red pigment was completed and the results published, and work on the copper corrosion product in ancient Egyptian bronze was continued. The collection of abstracts of Technical Studies in Art and Archaeology was concluded, and a new collection of abstracts for the International Institute of Conservation was begun. Additional specimens were added to the permanent collection for purposes of comparison, and a complete X-ray diffraction powder camera with track and bracket assembly was added to the laboratory equipment.

By invitation the following lectures were given outside the Gallery by staff members:

1953

Aug. 7. Mr. Stern gave a lecture at Fordham University on "The Exhibition of Japanese Painting and Sculpture Currently Touring the United States." (Illustrated.) Attendance, 35.

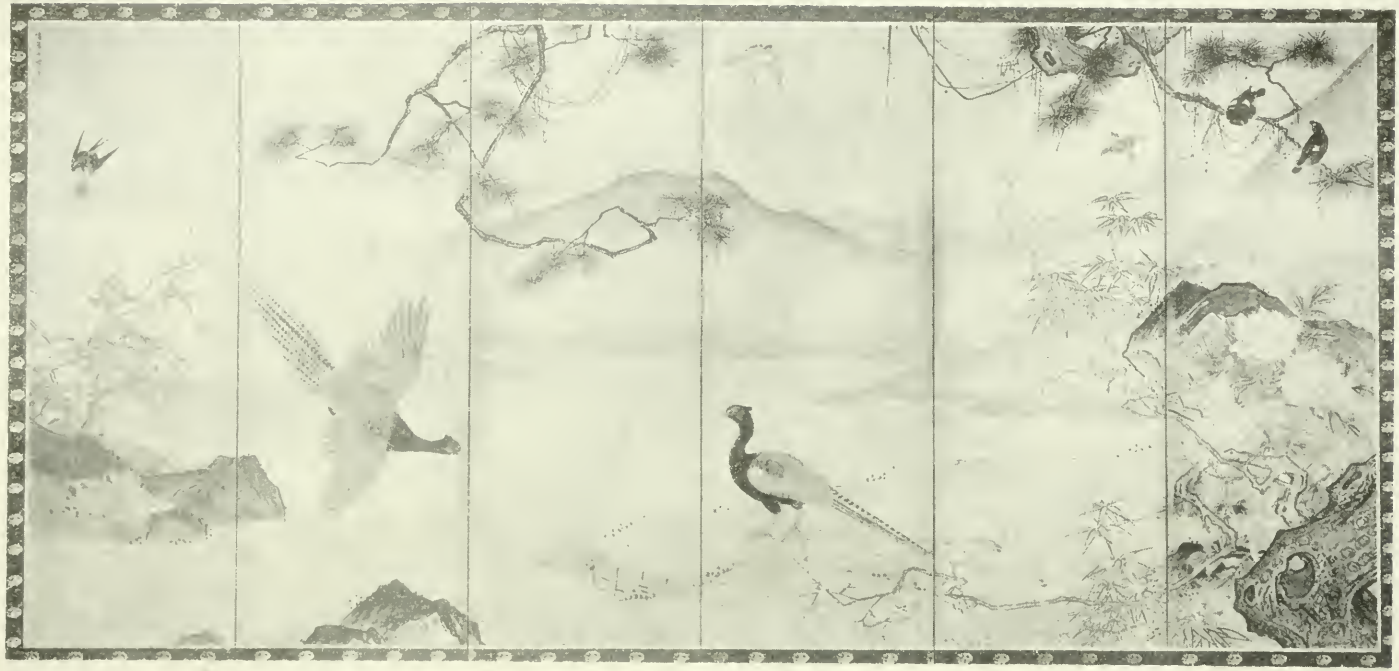


53.91



53.83

Recent additions to the collection of the Freer Gallery of Art.



53.94

Recent addition to the collection of the Freer Gallery of Art.

1953

Nov. 15. Dr. Ettinghausen gave a lecture at All Souls Unitarian Church, Washington, D. C., on "Travels in the Near East." (Illustrated.) Attendance, 80.

Nov. 25. Dr. Ettinghausen gave a lecture at the Baltimore Museum of Art on "The World of Muslim Art." (Illustrated.) Attendance, 75.

1954

Jan. 5. Dr. Ettinghausen gave a lecture at Bryn Mawr College, Bryn Mawr, Pa., on "Landscapes and Monuments in Iran." (Illustrated.) Attendance, 150.

Apr. 25. Dr. Ettinghausen gave an illustrated lecture to the International Avicenna Congress at the University of Teheran, Teheran, Iran, on "The Art of Iran at the Time of Avicenna." Attendance, 200. (Dr. Ettinghausen extended to the Congress, in Persian, the thanks of the American Delegation. This lecture is to be published in the Report of the Avicenna Congress for the Persian Government.)

May 17. Mr. Gettens gave a lecture to the Colorists of Washington and Baltimore at the Washington Y. W. C. A., on "The Story of Early Blue Pigments." (Illustrated.) Attendance, 22.

May 21. Mr. Pope gave a lecture to the Kiln Club of Washington in the auditorium of the U. S. National Museum, on "The Qualities of a Show-Worthy Pot." (Illustrated.) Attendance, 70.

June 9. Dr. Ettinghausen gave a lecture to the Iran-America Society, in Teheran, Iran, on "The Development of Iranian Art in the Moslem Period." (Illustrated.) Attendance, 200.

Members of the staff traveled outside of Washington on official business as follows:

1953

Sept. 21–Oct. 29 As a representative of the Smithsonian Institution, Mr. Gettens, associate in technical research, attended the Conference on Museum Laboratories held in Paris on September 25 under the auspices of the International Council of Museums. Mr. Gettens also traveled in Italy, Belgium, and England where he visited museums and laboratories to see the work being done and methods and techniques used in connection with the maintenance, care, and restoration of museum collections.

Oct. 3–5. Mr. Wenley attended the meeting of the Far Eastern Ceramic Group in Birmingham, Mich., and Cranbrook Museum of Art, Bloomfield Hills, Mich., where he read a paper for Mr. Gettens entitled "Seeing Red—True and False Vermilion on Early Chinese Ceramics." At the University of Michigan, Ann Arbor, Mich., he conferred with Prof. Max Loehr regarding use of the Freer Fund.

1954

Jan. 8–25. Mr. Pope was in London for the Loan Exhibition of Chinese Blue and White Porcelain held by the Oriental Ceramic Society, took part in a specimen meeting of the Society.

Apr. 12–18. Mr. Stern, in New York, attended the meetings of the American Oriental Society, April 13–15, delivering a paper on "A Pair of Sesshū Screens" (illustrated) on April 13.

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1954

Apr. 12–19. Mr. Pope, in New York, read a paper entitled "An Example of the Unreliability of Chinese Texts on Ceramics," at a meeting of the Art and Archaeology Section of the American Oriental Society.

Apr. 25. On the invitation of the Iranian Government, Dr. Ettinghausen, as a representative of the Smithsonian Institution, attended the celebrations in honor of the 1,000th anniversary of the birth of the great Iranian philosopher and physician Abu Ibn Sina, known in the West under the name of Avicenna. The ceremonies were held in Hamadan, Iran. In Iran he was studying private collections and museums as the year ended.

June 4. Mr. Pope was in Europe to attend the International Exhibition of Chinese Art held at Venice in celebration of the 700th anniversary of the birth of Marco Polo. He also visited the exhibition of Asiatic Art held in the Musée Cernuschi, Paris, in memory of Réné Grousset. He examined objects in museums and private collections and conferred with scholars in London, Paris, and Brussels.

In addition, 5 members of the staff made a total of 13 other trips outside of Washington on official business.

Members of the staff held honorary posts and undertook additional duties outside the Gallery as follows:

Mr. Wenley:
- Member, Visiting Committee, Dumbarton Oaks Research Library and Collection.
- Research professor of Oriental Art, Department of Fine Arts, University of Michigan.
- Member, Board of U. S. Civil Service Examiners at Washington, D. C., for the Smithsonian Institution.
- Member, Board of Trustees, Textile Museum, Washington, D. C.
- Member, Board of Trustees, Hermitage Foundation, Norfolk, Va.
- Member, Council of the Far Eastern Ceramic Group.
- Member, Smithsonian Art Commission.
- Member, consultative committee, *Ars Orientalis*.
- Chairman of the Louise Wallace Hackney Scholarship Committee of the American Oriental Society.
- Member of the House Committee, Cosmos Club, Washington, D. C.

Mr. Pope:
- President, Far Eastern Ceramic Group.
- Art Editor, *Far Eastern Quarterly*.
- Member, Editorial Board, *Archives* of the Chinese Art Society of America.
- Member, Board of Governors, Washington Society, Archeological Institute of America.
- American member, Consultative Committee for the International Exhibition of Chinese Art held at Venice in connection with the celebration of the 700th anniversary of the birth of Marco Polo.
- President, Association of the Southern Alumni of the Phillips Exeter Academy.

Dr. Ettinghausen: Research Professor of Islamic Art, Department of Fine Arts, University of Michigan.
Near Eastern editor of *Arts Orientalis.*
Member, Editorial Board, *The Art Bulletin.*
Trustee, American Research Center in Egypt.
Member, Comitato Internazionale di Patronato, Museo Internazionale delle Ceramiche, Faenze, Italy.
Member, Editorial Advisory Committee, and contributor to *Studies in Art and Literature in honor of Belle DaCosta Greene.*
Editor and contributor to *A Selected and Annotated Bibliography of Books and Periodicals in Western Languages Dealing with the Near and Middle East with Special Emphasis on Medieval and Modern Times,* Supplement No. 1, 1954; published by the Middle East Institute.
Delegate to the Avicenna Celebrations held in Iran, April 21–30, 1954.
During the fall semester, gave a course on Islamic miniatures to a class at Johns Hopkins University, Baltimore, Md.

Mr. Gettens: Consultant, Advisory Board of the Intermuseum Association.
Associate editor, *Studies in Conservation,* published for the International Institute for the Conservation of Museum Objects.
Abstractor for *Chemical Abstracts,* American Chemical Society.
Representative of the Smithsonian Institution at the conference on Museum Laboratories held in Paris on September 25 under the auspices of the International Council of Museums.
Sponsor of the Artists Technical Research Institute, 240 E. 20th Street, New York 3, N. Y.
Socio Corrispondente, Centro de Storia della Metallurgia (Associazione Italiana di Metallurgia), Via Moscova 16, Milano, Italy.
Attended a course in cleaning and laundering of ancient fabrics at the Textile Museum, Washington, D. C.; the course included lectures, laboratory work, and examinations. It was conducted by Col. James W. Rice, director of research, National Institute of Rug Cleaning, Silver Spring, Md.
Submitted a review of a dossier on painting for the Springfield Museum of Fine Arts.

Mr. Stern: On January 13 attended a meeting at Radio Station WCFM to assist in planning a series of programs concerning galleries, museums, etc. On February 25 read a paper on the history and activities of the Freer Gallery on the WCFM radio program, one of a series on "Our National Art Centers."

Respectfully submitted.

A. G. Wenley, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the National Air Museum

SIR: I have the honor to submit the following report on the activities of the National Air Museum for the fiscal year ended June 30, 1954:

GENERAL STATEMENT OF CONDITIONS

Conditions have improved in the National Air Museum relative to its two principal problems—the care of the stored material and the need for an exhibition building to house the national aeronautical collections.

Considerable progress was made during the year with the Museum's storage facility at Suitland, Md., but there remained the problem of transporting the stored collections from O'Hare International Airport, Park Ridge, Ill., where they were originally placed. By the close of the fiscal year, however, arrangements were being made for the allotment of Air Force funds for shipping this material. Many of the aircraft and all the engines require preservation treatment, several are yet to be dismantled, and those previously boxed need reinforcement before they can be shipped, but a target date of January 1956 was set for completing the move.

The problem of acquiring an adequate exhibition building to house the national aeronautical collections has become a vital one since the close of World War II. It will be recalled that Public Law 722 of the 79th Congress authorized the Museum "to investigate and survey suitable lands and buildings for selection as a site for said national air museum and to make recommendations to Congress." Comprehensive plans were prepared for a National Air Museum, but Congress did not act upon them. Since then these plans have been subjected to considerable modification including the proposal that the location be near existing Smithsonian buildings. Recently a plan has been originated for improving the southwest area of Washington south of the Smithsonian buildings. The planners have included a proposed Smithsonian museum and other cultural buildings in their layout, and Smithsonian officials have expressed their interest in such proposals.

In the meantime steps are being taken to determine the needs of the National Air Museum, including the size and cost of a site and building. It is a pleasure to report that the Aircraft Industries Association and the Air Transport Association have generously donated funds to cover the costs of this primary study.

The condition of exhibited material in the two buildings now containing aeronautical displays, although far from ideal is, nevertheless, a tribute to the zealous efforts of the staff and the exhibits workers. Space for displays remains a pressing problem. Cases are crowded, and the visiting public is constricted by the narrow aisles. The staff is constantly faced with the need to decide whether to display a new accession and add to the crowding, or to store it and thereby deprive Museum visitors of its educational and interest value. The number of accessions recorded this fiscal year is the greatest in the history of the National Air Museum—more than 20 percent above the highest previous year—and the number of visitors to the Aircraft Building this year was a third more than the previous high count. Requests to the Museum for information and service are constantly increasing, although the staff has had to be reduced because of lack of funds. This growing interest in the Museum certainly would seem to emphasize the need for better facilities both for exhibition and informational services.

The increasing demands of administrative work in the Washington office of the Museum have limited the time that could be allotted to trips for the purpose of surveying and procuring material for the Museum, but whenever time could be spared for such personal investigations, the results were always more productive and informative than those achieved by correspondence alone.

ADVISORY BOARD

Two changes occurred in the personnel of this Board which advises and assists in the administration of the National Air Museum. On July 1, 1953, Rear Adm. Thomas S. Combs was succeeded by Rear Adm. Apollo Soucek, representing the Chief of Naval Operations; and on June 16, 1954, Maj. Gen. Laurence C. Craigie was replaced by Maj. Gen. George W. Mundy, representing the Chief of Staff of the Air Force. No change was made in the original civilian appointees, Grover Loening and William B. Stout. While members of the Board have met occasionally, informally, no formal meetings were called by the Secretary of the Smithsonian Institution during the year. The members, however, have continued to help with a number of Museum projects and to stimulate progressive action on important developments.

STEPHENSON BEQUEST

Progress is being made in the matter of the bequest of George H. Stephenson of Philadelphia who provided for a statue of the renowned air leader Gen. William Mitchell, to be sculptured and presented to the National Air Museum. After consultations with a number of sculptors recommended by the Commission of Fine Arts, Bruce Moore

was selected. On June 11, 1954, Mr. Moore, with Alfred Verville, who was a close friend and aeronautical engineering associate of General Mitchell, and the head curator of the Air Museum, were received by Mrs. Thomas Byrd, widow of the General, who discussed the air leader's characteristics and qualities, lent a number of photographs of the general to the sculptor, and generously gave to the Museum a selection of the General's uniforms and other items associated with his military and aeronautical career, these objects to be incorporated in an exhibit associated with the statue when it is completed. The statue is to be one-sixth larger than life-size, full length, and mounted on a granite pedestal. It will occupy an honored place in the Aeronautical Hall of Fame, which is to be a feature of the proposed National Air Museum. Meanwhile, upon completion, it will be placed with General Mitchell's World War I SPAD airplane which has long been one of the most prominent exhibits in the Aircraft Building.

SPECIAL EVENTS AND DISPLAYS

As the calendar year 1953 approached, the staff of the Museum realized that the fiftieth year of powered flight would be a significant milestone of progress. Following the acquisition of the Wright brothers' original Kitty Hawk Flyer on December 17, 1948, the forty-fifth anniversary of its first flight, a concentrated effort was made by the staff to obtain related material, so that the complete story of the Wright brothers' aeronautical accomplishments could be assembled in tangible form, and the related files furnish authentication. Research for and acquisition of Wright memorabilia had been undertaken even before the Kitty Hawk Flyer was received, but the renewed effort brought encouraging results. In this quest the Museum had the valuable assistance of many persons who had known the famous brothers and whose knowledge was authoritative and intimate. As research progressed the staff was successful in locating several scale drawings and numerous photographs of Wright aircraft and activities. The Department of History of the U. S. National Museum cooperated by removing all of their display cases from the floor ahead of and beneath the Kitty Hawk Flyer so that a special Golden Anniversary Exhibit could be assembled in the most appropriate location, and the Smithsonian Photographic Laboratory and other service units assisted in preparations. The display was opened to the public the first week in December.

As the visitor to the Museum entered the front door he saw first individual sculptured portraits of the brothers, both sculptures the work of Oskar Hansen. These flanked a scale model of the monument erected to the honor of Wilbur and Orville Wright atop Kill Devil Hill. Nearby was the letter written by Wilbur Wright to the Smithsonian Institution on May 30, 1899, in which he stated:

I have been interested in the problem of mechanical and human flight ever since as a boy I constructed a number of bats [1] of various sizes after the style of Cayley's and Penaud's machines. My observations since have only convinced me more firmly that human flight is possible and practicable. . . . I am about to begin a systematic study of the subject in preparation for practical work to which I expect to devote what time I can spare from my regular business. . . . I wish to obtain such papers as the Smithsonian Institution has published on this subject, and if possible a list of other works in print in the English language. . . . I wish to avail myself of all that is already known and then if possible add my mite to help on the future worker who will attain final success.[2]

Beyond the sculptures and monument model was a full-scale reproduction of the Wright wind tunnel of 1901–2 with which the brothers developed their basic knowledge of aeronautics. Then, in a wide arc under the wings of the Kitty Hawk Flyer itself was a series of scale models and associated photographs illustrating the astounding fact that Wilbur and Orville Wright and the Wright Company, between 1900 and 1916, designed and constructed no less than 25 types of heavier-than-air craft, including the first to carry a passenger, the first to fly for an hour, the first to fly for two hours, the first military airplane to be put into practical service by any government, the first to rise a mile, the first to carry air express, the first to fly across the United States, and the first to fly while the pilot released the controls and an automatic stabilizer was used—all these supplementing that most wonderful "first" of all, the first heavier-than-air craft in the history of the world to carry a man in free, powered and controlled flight. A scale model of the Burgess Type H showed one of the several aircraft made by other companies under license from the Wright brothers, and a model of the De Havilland–4 illustrated a type produced by the Dayton Wright Company during World War I, when Orville was a director and engineer of that company. Three separately exhibited Wright engines were shown: an upright 4-cylinder of 25 hp., a 6-cylinder engine of 60 hp., and a later version of the 6, developing 70 hp. Supplementing these exhibits were five photographic displays illustrating Wilbur and Orville Wright's gliding experiments of 1900, 1901, 1902, and Orville's of 1911; their flights in Europe in 1908 and 1909; Orville's military demonstration flights at Fort Myer in 1908 and 1909; the schools established by the Wrights at Dayton, Ohio,

[1] Model aircraft.

[2] He was sent four Smithsonian pamphlets: "Empire of the Air," by Louis-Pierre Mouillard, "The Problem of Flying and Practical Experiments in Soaring," by Otto Lilienthal, "Story of Experiments in Mechanical Flight," by Samuel P. Langley, and "On Soaring Flight," by E. C. Huffaker. The reply also recommended a list of aeronautical books including "Progress in Flying Machines," by Octave Chanute, "Experiments in Aerodynamics," by Langley, and the "Aeronautical Annuals," edited by James Means, containing a number of reprints of early discourses on flight, and articles by experimenters of the late nineteenth century. When the Wright brothers were presented with the Langley Medal in 1909 by the Smithsonian Institution, Wilbur Wright referred to this early letter and its helpful reply.

Montgomery, Ala., and Augusta, Ga.; and some of the many awards, trophies, and honors bestowed on these famous brothers.

The Golden Anniversary Exhibit remained on display during December and was admired by thousands of visitors, particularly those who attended the Wright anniversary celebrations on the 17th.

A number of other special events and displays were held during the year. On July 17, 1953, a famous airplane, the Boeing 247–D, was brought to Washington on its own wings. The 247–D was one of the first passenger transports of modern design, and this particular one is the most notable of its type. In 1934 it placed third in the race from England to Australia sponsored by Sir MacPherson Robertson, being outflown only by a British De Havilland racer and by a Dutch team in another American transport—the Douglas DC–2. The 247–D was then brought back to the United States and became the flagplane of United Air Lines. After extended passenger service this 247–D was purchased by the Union Electric Co. and used as an executive plane until 1939. For the next 15 years it became a test plane for instruments, navigating devices, checking radio beams, making airways investigations, and filling other requirements of the Civil Aeronautics Administration. In that service this airplane earned the name of *Adaptable Annie.* Finally, after 20 years of strenuous performance and 10,000 hours in the air, the Civil Aeronautics Administration turned the aircraft over to the National Air Museum with appropriate ceremonies.

On July 22, 1953, the twentieth anniversary of Wiley Post's second world flight in which he made the circuit alone, guided in great measure by the Sperry robot pilot, the Sperry Gyroscope Co. presented to the Museum a special display in which Wiley Post's robot pilot is mounted in an exhibition case together with an operable example of the mechanism, which can be studied by Museum visitors through manipulation of controls.

August 12, 1953, was the seventh anniversary of the establishment of the National Air Museum. As one of the celebrations marking the fiftieth year of powered flight, Jennings Randolph, formerly Representative in Congress from West Virginia, who had been one of those responsible for establishing this Museum, chose that anniversary date to present to the Museum the original pen with which the President of the United States had signed the establishing act. At a Lions Club luncheon, Mr. Randolph spoke of his discussions with General of the Air Force, H. H. Arnold, at the close of World War II, regarding the importance of preserving significant aircraft because of their educational and inspirational value, and how the General and he had combined their ideas into the text which finally became law.

For the thirty-fifth anniversary of the establishment of Post Office Department–operated airmail, also celebrated on August 12, groups

of scale models and airmail relics were arranged as a separate exhibit in the Aircraft Building, and the head curator delivered a lecture on the history of postal aviation at the banquet of the Air Mail Pioneers when he was elected president of the local chapter of that organization. The Museum cooperated with the International Aviation Pioneers' dinner on October 14 by arranging a display of models and illustrations of Wright brothers' aircraft at the Mayflower Hotel where the banquet was held and on the next afternoon it was host to that distinguished group for a tour of the collection.

The North American F–51 airplane *Excalibur–III*, which still holds the propellered transatlantic speed record established on January 31, 1951, and which made the first solo flight over the North Pole on May 29, 1951, both flights piloted by Capt. Charles Blair of Pan American World Airways, was formally presented to the National Air Museum by Pan American on November 6, 1953.

For the annual Wright brothers' banquet conducted by the Aero Club of Washington at the Statler Hotel on the anniversary of the first flight, December 17, the Museum lent its series of enlarged photographs of Wright aircraft and the sculptures from the Golden Anniversary Exhibit. On December 29, the Chilean Air Force, through the air attaché, Col. Henrique Flores, presented to the Museum a scale model of the Bristol Monoplane in which Capt. Dagoberto Godoy of the Chilean Air Force made the first flight over the high Andes from Chile to Argentina, December 12, 1918. This presentation was attended by officials of those countries and the air attaché of the British Embassy, the airplane having been of British manufacture.

At the annual meeting of the Smithsonian Board of Regents, on January 15, 1954, selections of models from the Golden Anniversary Exhibit were shown. On March 18, the Ninety-Nines, an organization of women flyers of which Amelia Earhart was a founder and which includes many of the most prominent airwomen in America, presented to the Museum their 25-volume set of scrapbooks dating from October 1929, when they were organized. This forms a very useful reference work in connection with the many excellent accomplishments by women in aviation.

IMPROVEMENTS IN EXHIBITS

The two exhibits workers have made numerous improvements in the displays, in many instances with the much appreciated assistance of the service shop personnel of the Smithsonian. In several of the major projects, the donors or other interested parties assisted with these undertakings. The Civil Aeronautics Administration and United Air Lines aided in preparing the 247–D for storage, John Holzer, expert mechanic lent by United, being particularly helpful. Pan American Airways assigned one of their top mechanics, Robert

McCormick, to work with Museum personnel in preparing the *Excalibur–III* for exhibition. That project included dismantling and storing the *Polar Star*. The fabric on the *Eaglet* glider, which in 1930 was piloted by Frank Hawks from Los Angeles to New York City, had deteriorated so badly that re-covering was needed. This was expertly accomplished by Butler Aviation and financed by the Texas Co., the original sponsors and donors of this famous glider. The Pratt & Whitney Engine Division of United Aircraft Corporation assigned their public relations head, Kenneth Koyen, and one of their technical experts, Harvey Lippincott, to assist in improving the display of their Wasp No. 1 engine of 1925 and the Wasp Major engine used on the nonstop world flight of the Air Force *Lucky Lady* B–50 bomber in 1949. Assistance from this corporation included the design and construction of a special stand for the latter engine.

Additions to the group of photographs and specimens illustrating the awards of the Collier Trophy have, together with better labeling, improved that exhibit; while the procurement of other famous trophies has added to the attractiveness and significance of the trophy display. By relocating a group of large models of current transport airplanes, several guided missiles, a display on the German V–1 Buzz Bomb of World War II, and several of the trophies, noteworthy improvements were made in the general appearance of Aeronautical Hall; and an exhibit associated with Wiley Post and his famous world and stratosphere flights was moved and renovated to form a companion case adjacent to his Sperry robot pilot. A number of the airplanes including the Curtiss "Jenny," Fokker D–7, Loening Amphibian, the hull of the NC–4, and the cockpit of the World War II fighter Republic F–84, received more than the usual requirement of maintenance.

STORAGE

At the Museum's Park Ridge, Ill., storage facility more than a third of the fiscal year was spent in moving the storage material in compliance with requirements of the Air Force, which maintains administrative and flight operations at that airport. Each of these moves involved the repeated handling of several hundred items, including large and heavy aircraft boxes, while the moves from Building T–7 to Building T–6, and within T–6, required each time the reestablishing of the office area, shop equipment and supplies, and all the many service connections needed to operate the tools, cleaning equipment, and preservation gear.

Despite these delays the personnel at Park Ridge, when finally able to resume the normal operations of the storage facility, shipped to Suitland, Md., 21 aircraft involving 38 boxes, many of which had to be repaired before shipment because of damage sustained by long out-

door exposure; cleaned and gave preservation treatment to 24 engines, of which 9 were boxed, and 2 shipped; boxed and shipped 142 component items; disassembled 10 aircraft, several being large twin-engined foreign airplanes; packed 5 of them, requiring 11 boxes, and partially packed 4 of them into 8 boxes; repaired and weatherproofed 26 large aircraft boxes which had been badly damaged by high winds, and spray-coated 17 big boxes with protective covering. There were also numerous maintenance projects including care and repair of handling equipment, machinery, and tools. All this work was accomplished largely by a group of four men: the manager, Walter Male, two mechanics, and one carpenter, while the five guards assisted, between patrols by sorting and tagging material being packed, and with preservation and maintenance projects. For two of the moves the Air Force assigned enlisted men to help carry material.

In 1951, when the Air Force believed that Building T-6 could be reactivated as an airplane factory, and the Museum was sent the first notice to clear its material from the building, arrangements were made to fly out several airplanes that were serviceable. They were stored at Pyote Air Force Base in Texas. In September 1953, the Museum was notified that they could not remain there as that base was to be closed. Andrews Air Force Base, near Washington, agreed to receive these airplanes and permit them to remain there until the Museum can take them on its own premises, and the Air Force graciously furnished the flight crews and flew these planes in.

At the Suitland, Md., storage area, located about 5 miles from the Smithsonian exhibition premises, the principal accomplishment during the fiscal year was the construction under contract of a large 5-unit prefabricated storage building, which adds 20,000 square feet of indoor space to the 24,000 provided the previous fiscal year. The shipments from Park Ridge and the aircraft and material received from other sources were accommodated within Buildings 1 to 6, the large Building 7 not being completed until after their arrival. By the middle of May plans were under way for extending the road to give access to sites for the remaining five buildings to be erected. Economies in Smithsonian expenditures, and cooperation from other bureaus of the Institution, made it possible to purchase material for four of those five buildings and to finance a fence to enclose the entire 21-acre area. Contracts for these improvements were made through the General Services Administration. The U. S. Army Engineering School at Fort Belvoir, Va., was very kind to consider the extension of the roadway as a practical school project and assigned officers and men with a huge bulldozer to cut the way through the wooded area. Air Force personnel and equipment from nearby Bolling Air Force Base then covered that roadway with gravel brought from Andrews Air Force Base, and lent trucks, a scraper, and small bulldozer to smooth and

level the new road and also fill the ruts and hollows on the entrance roadway. This completes the loop as drawn in the original plans. Andrews Air Force Base also lent a quantity of pierced steel planking for temporary road reinforcement. The Navy Department, Bureau of Yards and Docks, assisted in preparing the specifications and processing the contracts for the Museum's storage buildings at Suitland. Additional assistance from Bolling Air Force Base was often given for unloading heavy shipments beyond the capacity of the Museum's handling equipment; and mention of this equipment recalls the efficient services of the Smithsonian property officers who, with the cooperation of the Army and Navy and General Services Administration, obtained two large forklifts and a crane at a cost for transportation only. These machines were made serviceable through the help of the Smithsonian service shop personnel and the Museum's exhibits workers. Maintenance projects included painting of six building roofs, clearing stumps and brush, and sawing the felled trees into boards to be used for shoring and shelving.

Thus, although the amount requested in the budget estimate of the fiscal year 1954 for construction and utilization of the Suitland storage facility was not granted, much progress has been made toward completing this greatly needed auxiliary.

COOPERATIVE AND EDUCATIONAL SERVICES

Requests for aeronautical information and educational material are constant and, as the resources and abilities of the Museum and staff become better known, are increasing. The staff is pleased to give such assistance to the best of its ability. The following are typical examples of the kinds of services rendered:

A number of Government departments were assisted. The Library of Congress and the Museum have been of mutual assistance in developing files relating to the Wright brothers. Air Force engineer officers preparing a technical study of aircraft structures were given a chronological review illustrated by specific examples in the collection; Kelly Air Force Base was furnished biographical data on Lt. George M. E. Kelly, for whom that base was named; and the flight school at Laredo was helped with the writing of articles and with photographs for its students' yearbook. Many Air Force officers visited or phoned for technical and historical facts; the subjects ranged from details of the first World Flight of 1924, biographies of noted airmen, and flight performances of famous airplanes, to clarification of technical terms in foreign translations. The Air University was supplied with a group of photographs illustrating aircraft of the Wright brothers. Authors for Naval Air publications were assisted in identifying photographs of aircraft and in preparing articles. Material and information were supplied for an exhibit on aircraft-carrier history and for a

display of early aircraft radio installations; Naval research engineers requested the loan of a scale model of the Grumman F6F for use in ordnance studies and were particularly pleased to be shown in the Museum a piece of early equipment which embodies elements applicable to important current studies. Both the Air Force and Navy were helped in planning their Armed Forces Day exhibits. The General Services Administration Archives Division was aided in identifying a number of old aeronautical photographs; the Civil Aeronautics Administration was given illustrations for a text on the Wright brothers; and the U. S. Office of Education was provided with a monograph on the Wrights which they copied and distributed to the many delegates at the educational meeting held in Atlantic City.

For the fiftieth anniversary celebration held at Kitty Hawk, N. C., December 14–17, and as a permanent addition to the Wright brothers' memorial there, the Department of the Interior reconstructed the two buildings erected north of Kill Devil Hill by Wilbur and Orville Wright to house their aircraft and themselves during their experiments of 1902–3, and upon their later return. This reconstruction was in line with a suggestion proposed several years ago by this Museum, and the staff was pleased to assist with additional ideas and information. Investigators of the Department of Justice continued to call upon the Museum for examples of equipment and related facts under discussion in current claim suits, and the Weather Bureau received assistance in preparing displays on aircraft meteorology. The Republic of Guatemala was furnished with photographs and information for a historical aviation display honoring the Wright brothers.

Many aeronautical organizations, airlines, and manufacturers were assisted by the Museum. The National Aeronautic Association honored the head curator by appointing him as one of its directors. Early Patent Office models of aeronautical inventions were lent to the Johns Hopkins Applied Physics Laboratory for use in an exhibit intended to encourage local inventors, and the Schebler Carburetor Company received aid in tracing some of their early types used on aircraft engines. Both Trans-World Airlines and United Airlines were lent scale models of aircraft associated with their history, American Airlines was given facts about early engines, and Pan American World Airways was assisted in conducting a model airplane contest. A historian from Chance Vought Aircraft of Dallas, Tex., was helped in preparing a company history, and that company has reciprocated by preparing models and photographs of its types for the Museum series. The Early Birds, an organization composed of pioneer fliers, was lent an authentic Wright propeller to serve as a pattern for a bronze casting which is to be incorporated in a memorial to those who flew at Governors Island, N. Y., before the first world war. The Aircraft Industries Association was aided in preparing a historical article

on helicopter development, and the Air Transport Association was given facts about the P. R. T. Airline of 1926 and the Washington Hoover Airport for a chronological treatise. The Air Force Association was provided with maps, photographs, and texts pertaining to the first transcontinental flight, made in a Wright brothers' airplane and requiring 84 days and 70 landings, in 1911. This association plans to erect a marker at Pasadena, Calif., in memory of the pilot Calbraith Perry Rodgers.

The results of Museum assistance to artists have been apparent in authentic aircraft paintings and drawings for Life, Aero Digest, and the Saturday Evening Post, while other magazines and publishers aided by Museum material and information during this year include the National Geographic Society for its December aviation issue, the Book of Knowledge, Collier's Encyclopedia, and the World Book, which were supplied with aeronautical photographs. A pictorial history of aeronautics, "Flight," compiled by the publishers of Year includes many views selected at the Museum. Among the universities that requested assistance from the Museum are the Catholic University in Washington, D. C., and the State universities of Illinois, Colorado, Nebraska, and Maryland. Several museums were helped with current projects. The Dayton Art Institute was furnished with illustrations of old Chinese kites for an exhibit on early ideas on flight; the Kern County Museum of California was supplied with a selection of air-history photographs; the Deutsches Museum in Munich, Germany, which is trying to repair the ravages of war among its aircraft material, was sent drawings of a Wright brothers' Type A Flyer; and the Musée de l'Air in France was furnished information about the Japanese Kamikaze rocket-bomb aircraft in the National Air Museum.

With the continuation of celebrations by the air fraternity, directed by the national and local committees associated with the Fiftieth Anniversary of Powered Flight, which culminated with the close of the calendar year 1953, the Museum experienced the greatest demands yet made upon its informational services.

Requests to the Museum for lectures on widely varied aeronautical subjects were particularly frequent during the anniversary year and continued into the remainder of the fiscal year. Among the 23 lectures given by the head curator in the 12-month period were those to the Pan American World Airways Management Group at Miami, Fla., October 13; to the Columbia Historical Society of Washington, D. C., October 20; to the large group celebrating the Fiftieth Anniversary of Powered Flight at Ithaca, N. Y., December 8; before the National Airport Club, Alexandria, Va., January 7 (which resulted in that club's adopting a motion to cooperate with the Museum in its need for an adequate building for the aircraft collection); on January 27, at Sampson Air Force Base, New York, to a double assembly of about 5,000 student

airmen; to the full brigade of U. S. Naval Reservists of the Potomac River Naval Command, February 10; the annual Ruediger Lecture at George Washington University in Washington, D. C., March 1; and before the Royal Air Force Club in Washington, D. C., on April 15. Most of these lectures were illustrated with films and slides and described various aspects of the history of aeronautics, with emphasis on the outstanding accomplishments of Orville and Wilbur Wright.

Because of the small staff and the pressure of work it is seldom possible to conduct groups on tours of the exhibits, but when this can be done it is mutually helpful. Among the 12 tours conducted were those for about 150 Civil Air Patrol cadets and a nearly equal group of foreign cadets in July; a group of engineers associated with the Air Transport Association and the Radio Technical Commission in October; and nearly 200 teachers of aeronautics from all over the United States during the special Wright brothers' celebration on December 17.

The National Air Museum furnished material for many radio and television programs. It is gratifying to know that the special television series arranged for schools by Mrs. Marjorie Campbell, a Washington science teacher who received assistance from the Museum, was given highest place in a nationwide rating. The TV shows based on the national aeronautical collection and conducted by John Daly, Ed Murrow, and Dave Garroway were widely acclaimed.

RESEARCH

Two of the Museum's special study projects have been materially advanced during the year. These are the origin and history of the guided missile in America and the pictorial history of the Wright brothers. Both have been conducted largely by Associate Curator Robert Strobell.

There were two contemporary American projects for producing guided missiles in World War I, identified respectively by the developments of Elmer A. Sperry and his son Lawrence for the Navy and by Charles F. Kettering for the Army. It is significant to recall that Orville Wright was associated with the latter undertaking. Museum research has progressed to the extent that enough material is available on the Kettering project to prepare drawings for a scale model, publish the findings, and assemble an authentic record in the permanent file of the Museum. Less information has been obtained on the Sperry missile, and research will continue as opportunity permits and cooperation is extended. A number of the interesting facts thus far revealed are embodied in an illustrated article, "America's First Pilotless Aircraft," published in the July 1954 Aero Digest, co-authored by Rear Adm. Delmar S. Fahrney, U. S. N. (ret.), and Mr. Strobell.

Because the national aeronautical collection includes three original

Wright brothers' aircraft, six of their engines, numerous scale models, and other related specimens, an associated project to procure significant pictorial material is well justified. Remarkable progress as been made this year in acquiring and correlating photographs of the Wright brothers, of historic events associated with their accomplishments, views of their aircraft in flight and on land or water, and technical details of their aircraft, engines, launching gear, instruments, and other devices. Excellent cooperation has been received from Underwood & Underwood, the New York Times, Culver Service, Frederick Lewis, European Picture Service, Brown Brothers, and the Institute of Aeronautical Sciences. S. W. Dunham, of Bellbrook, Ohio, and M. W. Todd, of Dayton, have been very cooperative, as have numerous other collectors and historians throughout America and Europe. As a result of this widespread interest in assembling in one appropriate place a complete record, the Museum's Wright brothers' pictorial collection has tripled in size this year and may be said to be the largest of its kind, although considered about three-fourths complete. It now numbers about 2,500 prints. Many interesting facts about the Wright brothers, biographical, technical, and historical, have come to light through this research, and as one direct result the series of 25 scale exhibition models of Wright types is nearing completion and becoming a valuable accessory to the original aircraft, further expanding public knowledge about the accomplishments of these famous pioneers of the air.

THE LINK FOUNDATION

In January 1954 an announcement was made by Edwin A. Link, chairman of the board of Link Aviation, Inc., Binghamton, N. Y., that the Link Foundation had been established to advance training and education in aeronautics. The Secretary of the Smithsonian Institution was appointed a member of the Technical Assistance Board, and Miss Marilyn Link, sister of the founder, is executive secretary. Her office is at the Smithsonian Institution. One of the first grants by the Link Foundation was to the Smithsonian, to be applied to the preparation and publication of a booklet describing 12 of the famous aircraft in the collection.

IMPROVEMENTS IN REFERENCE MATERIAL

During the Secretaryship of Dr. Samuel P. Langley, third head of the Smithsonian Institution, 1887–1906, he began collecting aeronautical books and reference material. Later, extracts from periodicals and newspaper articles collected during the first decade of this century by Alexander Graham Bell were added. Thus the Smithsonian became rich in data pertaining to the early days of aviation. This library is constantly expanding. During 1953 a number of current books, as well as earlier editions, were added, and the periodical

section of the library was improved. From the U. S. Book Exchange many magazines were received to fill gaps in the series; and from numerous private collectors and several commercial sources more missing copies and several bound volumes were obtained. The addition of this valuable source of contemporary information has enabled the staff to better perform its duties of labeling specimens and answering queries.

For every specimen recorded by the Museum an accession record or reference-file jacket is maintained. These jackets are constantly being improved and serve as a source of supplementary data for the staff and for visitors desiring more information than is given on the specimen labels. In the same reference file, jackets are kept on widely varied subjects associated with aeronautics. Many friends of the Museum send in items from time to time which are helpful. This year Ray Fife of Coronado, Calif., Fred Becchetti of Des Moines, Iowa, James Murray of the Boeing Airplane Co., E. T. Pachasa of the Cleveland Model Products Co., and Hideya Ando of Tokyo, Japan, have been very cooperative. Mr. Ando sent in a book on Japanese aircraft of World War II, which is of much assistance in describing the types of that nationality in the Museum collection.

Frequently publishers and others send in extra copies of their publications. The Fairchild Airplane and Engine Corporation donated 300 copies of their reprints of Walter Bonney's excellent historical article "Preclude to Kitty Hawk" and a quantity of Fred Neely's complete issue on the Collier Trophy. The Chance Vought Aircraft, Inc., supplied drawings of their early VE7–H airplane, and a number of other donations have been received. Selections of duplicate material have been sent to teachers and studies, and to other inquirers during the year.

The care of retained reference items in the permanent file is a constant necessity. During this year about a hundred file cases released by another Government department were taken to the Suitland storage area, and in them the large quantity of Air Force data, known as Technical Orders, was filed, following screening and sorting. This information is most useful in conducting the dismantling of aircraft now in progress at Park Ridge and will be even more necessary as the assembly of these aircraft is undertaken, following acquisition of an adequate building for exhibiting the collection. The photographs illustrating aircraft developed by the Aeromarine Co., by Curtiss, and by Curtiss-Wright, the first-named group received last year, and the others this year, were given preservation treatment.

Documentary additions to the collection include the original perspective drawing of the Wright brothers' Kitty Hawk Flyer, made by Ralph McLarren of Aero Digest, given by the artist. An enlarge-

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ment of that drawing formed the background for the Aero Club of Washington's Fiftieth Anniversary of Powered Flight banquet on December 17. A copy of Frank Jefferies' detailed drawing of the Air Force's Boeing P–26 fighter has also been received from the original artist. Pan American World Airways arranged for the painting of a scene representing their first flights to the Orient to illustrate the Collier Trophy award of 1936 to that Airway. Joseph Nieto, whose excellent drawings of aircraft are often featured in current magazines, continued to send large-scale copies for the Museum files. Robert Nevin, of Baltimore, Md., generously lent his large collection of photographs and data pertaining to Glenn Martin aircraft, so that prints and notes could be copied.

For the following lots of reference material entries have been made in a separate acknowledgment file:

Air Force, Department of, Wright-Patterson A. F. B., Ohio: A large selection of Technical Orders containing data on recent and current aircraft.

Berliner, Henry A., Riverdale, Md.: Copies of the James Means' Aeronautical Annual for 1897, books on aerodynamics by Gustave Eiffel, and the loan of a scrapbook of early aviation by James Lee Simmons.

Brown, Maj. Kimbrough S., U. S. A. F., Fort Walton Beach, Fla.: 71 books and pamphlets pertaining to aeronautics, the majority relative to the World War I period.

Clemmons, Mrs. Anna B., Saratoga Springs, N. Y.: A collection of 654 photographs and 2 booklets of early Curtiss aircraft.

Coen, Mrs. Cutler, Pensacola, Fla.: An original souvenir program of the 1910 Belmont Park Air Meet.

Collins, Isobel V., Washington, D. C.: 39 photographs of Bell airplanes, 37 of them illustrating the P–39 *Airacobra*, and 2 of the XFM–1.

Curtiss-Wright Corporation, Wood-Ridge, N. J.: 208 photogrophs of aircraft produced by Glenn H. Curtiss, the Curtiss Aeroplane and Motor Co., and the Curtiss-Wright Corporation.

Emig, Mrs. C. E., Washington, D. C.: A collection of slides prepared by the late Maj. Emig during World War I, and used for educational lectures on aircraft construction and operation.

Gabrielli, G., Torino, Italy: A collection of 103 photographs of Fiat aircraft and engines, 6 pamphlets describing Fiat products and activities, a book, *Fiat, a 50 Years' Record*, and a group of 4 small scale models of Fiat airplanes.

Harwood, Mrs. Georgia, Manteo, N. C. (through the interest and help of Aycock Brown): 22 original photographic negatives taken by the late VanNess Harwood illustrating Orville Wright's glider experiments in 1911 when Wright was developing his automatic stabilizer.

La Grone, Mrs. John K., Kansas City, Mo.: 50 photographs of aircraft, mainly of the period before and during World War I, flown by or associated with the late "Tex" La Grone.

Lippincott, Harvey H., Hebron, Conn.: A collection of books, pamphlets, and other printed reference material relative to current and recent types of aircraft and engines.

National Cash Register Co., Dayton, Ohio (through Carl Beust): 271 photographs pertaining to the Wright brothers, including interior views of their home, and of Orville's laboratory, and many of the Wright brothers' aeronautical activities.

NAVY, DEPARTMENT OF THE, Washington, D. C.: Blueprints showing construction details of the German Me–163 rocket interceptor airplane, and of miscellaneous equipment including guided missiles made in Germany during World War II.

NINETY-NINES, INC., San Francisco, Calif. (through Ruth N. Rueckert): The 24-volume scrapbook-history of this renowned organization of licensed women fliers, dating from 1929.

POLITIS, JACQUES N., Paris, France: 16 photographs illustrating flights by Wilbur Wright in France in 1908 and 1909.

REHDER, HARALD, Washington, D. C.: 36 illustrations of aircraft collected at the Rheims, France, Aviation Meet in 1909.

WRIGHT, THEODORE P., Ithaca, N. Y.: An album of Curtiss aircraft photographs.

ACCESSIONS

This year the Museum received 360 specimens from 48 sources, comprising 55 separate accessions. Those from Government departments are recorded as transfers, others were received as gifts, except as noted. Each has been entered in the permanent records of the Museum and formally acknowledged.

AIR FORCE, DEPARTMENT OF, Washington, D. C.: Douglas XB–43, America's first jet-propelled bomber, an experimental project of the U. S. Air Force (N.A.M. 796). Fuselage of the Douglas XB–42 "Mixmaster" experimental attack bomber, 1944 (N.A.M. 789). German rotary-wing autogiro kite FA–330, piloted, for use with submarines in World War II (N.A.M. 794). Prewitt Rotorchute, used for dropping equipment under extreme conditions of speed and stress beyond the limits of conventional canopy-type parachutes (N.A.M. 790).

ALL WOMAN TRANSCONTINENTAL AIR RACE, INC., San Diego, Calif.: Trophy awarded annually since 1947 to first-place winner of the Transcontinental Air Race, sponsored by the Ninety-Nines, Inc., and the National Aeronautic Association. (N.A.M. 814).

ASTON, ARTHUR C., Chevy Chase, Md.: Scale model, about 1:12 size, of a 12-cylinder Liberty engine of the World War I period (N.A.M. 799).

ATLAS SUPPLY CO., Newark, N. J., with cooperation of the Douglas Aircraft Co., Inc., through Mrs. Margaret Bedford and Col. E. E. Aldrin: Scale model, 1:16, of the Douglas DC–4 airplane named the "Atlas Sky Merchant" which operated throughout the world, 1946–1953, as a "flying show case" (N.A.M. 801).

BENDIX AVIATION CORPORATION, Eclipse-Pioneer Division, Teterboro, N. J., through E. O. Cooper: The engine-driven supercharger produced by this company for the Pratt and Whitney engine of the airplane *Winnie Mae*, and used during the high-altitude performance and pioneering substratosphere flights by Wiley Post in 1935 (N.A.M. 800, loan).

BUSHEY, FRANK B., Hartford, Conn.: A panel of original rubberized fabric from a Curtiss pusher-type biplane flown by M. Bonnetti, about 1909 (N.A.M. 809, loan).

BYRD, MRS. THOMAS, Boyce, Va.: Uniforms, flight equipment, and flags of Brig. Gen. William Mitchell (N.A.M. 811).

CHILEAN AIR FORCE, through Col. Enrique Flores, air attaché to the Chilean Embassy, Washington, D. C.: Scale exhibition model, 1:16, of the Bristol Monoplane Type M.1C in which Capt. Dagoberto Godoy of the Chilean Air Force, on December 12, 1918, made the first flight from Santiago, Chile, to Mendoza, Argentina, over the high Andes (N.A.M. 824).

Chrysler Corporation, Plymouth Division, Detroit, Mich.: The Plymouth Jet Trophy, a current award and perpetual trophy for model airplane competition (N.A.M. 831).

Civil Aeronautics Administration, Washington, D. C., through Fred B. Lee: The Boeing 247–D transport airplane *Adaptable Annie*, flown by Roscoe Turner and Clyde Pangborn in the MacRobertson Race, 1934, later flagplane of United Air Lines and until recently used by the C. A. A. in connection with its airways operations (N.A.M. 823).

Civil Air Patrol, Washington, D. C., through Gen. Lucas V. Beau: A barograph of current type constructed by Peravia, Ltd., Bern, Switzerland (N.A.M. 827).

Cochrane, Jacqueline, New York, N. Y.: Flag used at headquarters in England of the Air Transport Auxiliary, an organization of women fliers who performed valuable and patriotic service in ferrying military aircraft during World War II (N.A.M. 826).

Cueran, John J., Long Island City, N. Y.: Five parts of aircraft associated with the donor's extensive aeronautical experience. An angle of incidence indicator from his Bleriot Monoplane 1913, the propeller from Matthew Sellers Quadruplane of about 1910, a radiator apparently from a Martin TT airplane of 1913, a propeller from a British F. E. 2B airplane of World War I, and a radiator shutter from a Vought VE7–H airplane of 1920 (N.A.M. 816).

Douglas Aircraft Co., Inc., El Segundo, Calif., with cooperation by the U. S. Navy, Bureau of Aeronautics: Four scale models, 1:16, of current types of Naval airplanes produced by Douglas; the AD5W "Skyraider," A2D–1 "Skyshark," A3D "Sky Warrior" carrier attack plane, and the F4D–1 "Skyray" (N.A.M. 805).

Fales, E. N., Washington, D. C., through P. L. Ritchie, Dayton, Ohio: Three blades from rotors of the U. S. Air Service Engineering Division helicopter developed by Dr. George De Bothezat and Ivan Jerome, 1922–24 (N.A.M. 803).

Goodyear Aircraft Corporation, Akron, Ohio: A canopy for a U. S. Air Force F–84 Republic "Thunderjet" fighter, a type used in the Korean War, 1953 (N.A.M. 795).

Hartigan, Col. John D., Washington, D. C.: A silver insigne pin in the form of an American flag within a circle, worn by members of the First Aero Squadron, A. E. F., World War I (N.A.M. 798).

Hubbell, Charles H., Cleveland, Ohio: Six scale exhibition models, 1:16, of aircraft produced by Orville and Wilbur Wright and the Wright Company. These are the gliders of 1901 and 1911, the military Type C, the floatplane CH, and the Aeroboats Type G–1913 and G–1914 (N.A.M. 833, purchase).

Jones, Joseph W., New York, N. Y.: Two airplane instruments—a "Victometer" tachometer and an air-speed indicator, manufactured during the World War I period by the company established by the donor (N.A.M. 822).

Kemble, Lt. Comdr. Parker H., USNR (Ret.), Marblehead, Mass.: A propeller from a Burgess-Dunne airplane in which the donor and Geoffrey Cabot conducted air-pickup tests in November 1917 (N.A.M. 817).

Kennell, Capt. Louis C. and Vina, Hollywood, Calif.: A German Pfalz D–12 fighter airplane of World War I (N.A.M. 793).

Lewis, Leonard L., Oklahoma City, Okla., through C. H. Hubbell: A Harding parachute, made about 1917 and used in over 200 jumps including the first by Wiley Post, who in 1924 made exhibition jumps to help finance his flying lessons. The donor, who holds Commercial Pilot License 163, used this chute during his barnstorming days, shortly after World War I (N.A.M. 806).

Library of Congress, Washington, D. C.: The Richard anemometer from the estate of Octave Chanute, lent by him to the Wright brothers during their early experiments at Kitty Hawk so that duration and air speeds could be

measured (N.A.M. 797); a collection of 166 medals and 6 plaques associated with aeronautical history and formerly a part of the Paul Tissandier collection; and an electric lamp used by Adm. R. E. Byrd during an Antarctic expedition (N.A.M. 785).

LINK AVIATION, INC., Binghamton, N. Y.: An early Link trainer, 1929, embodying the initial developments of Edward Link for simulating flight conditions (N.A.M. 820).

MCDONNELL AIRCRAFT CORPORATION, St. Louis, Mo.: A portrait and a memorial album commemorating the accomplishments of Woodward Burke, test pilot, who lost his life while testing the McDonnell XFD–1 "Phantom." The portrait is by his widow, Olivia Bendelari Burke (N.A.M. 791).

MOORE, HERBERT R., Washington, D. C.: A contemporary insigne of the 94th Squadron, famous American air unit of World War I, in which the donor was an enlisted mechanic (N.A.M. 825).

MUSÉE DE L'AIR, Paris, France, through the Conservateur, Charles Dollfus: The original fuselage panel of fabric from the Breguet airplane, "Point d'Interrogation," in which Dieudonne Coste and Maurice Bellonte made the first flight from Paris to New York, 1930 (N.A.M. 830).

NATIONAL AERONAUTIC ASSOCIATION, Washington, D. C.: The Pulitzer Trophy, donated by the Pulitzer brothers as an incentive for air racing with land planes and awarded annually from 1920 through 1925 for the fastest time over a closed circuit course (N.A.M. 786).

NAVY, DEPARTMENT OF, Washington, D. C.: Scale exhibition model, 1:16, of the Richardson 82–A seaplane. The original was constructed at the Washington Navy Yard, 1916, and was the first airplane designed and built by the U. S. Government (N.A.M. 819). Through the British Royal Navy, a propeller from the first airplane of U. S. Navy type accredited with a victory in World War II (N.A.M. 828). A series of 8 meteorological displays illustrating weather conditions and explaining their relation to flight operations (N.A.M. 829). A complete PK–2 life raft exhibit showing equipment furnished Naval pilots for arctic survival in event of a forced landing; four crash helmets of types issued to Naval jet pilots; an airplane ejection seat with mannequin dressed in flight gear; a Naval aviator's oxygen-breathing system; and an aviator's vest incorporating nylon padding as protection against bullets and flak (N.A.M. 836).

NEVIN, ROBERT S., Baltimore, Md.: Scale exhibition model, 1:16, of the De Havilland DH–4 airplane as manufactured by the Dayton Wright Co. for service in World War I (N. A. M. 808, loan).

NEWCOMB, CHARLES, Bethania, N. C.: Scale exhibition model, 1:16, of the Wright brothers' aeroplane flown by Wilbur in Europe, 1908; a model to same scale of the catapult tower, track, and truck used to launch this and other Wright Type A aeroplanes; and a 1:16 model of the military tractor airplane Type H of 1912 made by Burgess and Curtis, licensed by the Wright brothers (N.A.M. 837, purchase).

NORTH AMERICAN AVIATION, INC., Los Angeles, Calif.: A group of 6 scale exhibition models, 1:16, illustrating types developed by this company for the Armed Services—the B–25–J "Mitchell" medium bomber, F–51–D "Mustang" fighter, F–86–E "Sabrejet" fighter, FJ–2 "Fury" carrier-based fighter, AJ–1 "Savage" Naval attack plane, and the AT–6 "Harvard" trainer (N.A.M. 812).

PERRY, ROBERT L., New London, Conn.: Awards collected by and issued to the donor's grandfather, A. Holland Forbes, early spherical balloon pilot and president of the Aero Club of America (N.A.M. 821, loan).

PLAHTE, LT. COL. FRED L., Fort Lewis, Wash.: A Japanese tubular gun camera of the type mounted on aircraft for photographing the effect of offensive fire (N.A.M. 835).

PORT OF OAKLAND, Oakland, Calif.: A BBT light used for the original airport-lighting installation at Oakland Airport; and a gasoline tank from the Italian transpolar airship "Norge" 1926 (N.A.M. 807).

PUMPHREY, MR. AND MRS. CHARLES, Washington, D. C.: A world globe on which several noted aviators and air navigators, including Wiley Post, Harold Gatty, and Roger Q. Williams, personally inscribed the course of their long-distance flights (N.A.M. 810, loan).

PURDUE UNIVERSITY, Lafayette, Ind.: A collection of medals, awards, keys to cities, and other trophy items presented to or in honor of Amelia Earhart, first woman to fly across the Atlantic Ocean, 1928; first woman to pilot her airplane solo across that ocean in 1932; and in 1935 to fly solo from Hawaii to California across the Pacific (N.A.M. 802, loan).

RANDOLPH, HON. JENNINGS, Washington, D. C.: The pen with which the President of the United States, Harry S. Truman, on August 12, 1946, signed the Act establishing the National Air Museum. That Act (Public Law 722 of the 79th Congress) was authored by the donor with General of the Air Force H. H. Arnold (N.A.M. 813).

REARWIN, KENNETH R., La Jolla, Calif.: An Anzani aircraft engine of radial form, Type B, manufactured in France about 1925, 6-cylinder, 45 hp. (N.A.M. 804, loan).

RICHMOND, LT. JACK, USAF (Ret.), Los Angeles, Calif.: Helmet and goggles worn by him during training at Love Field, Dallas, Tex., World War I. Autographed by famous aviation personalities (N.A.M. 787).

RINALDI, VICTOR, Arlington, Va.: Scale exhibition models, 1:16, of two Wright brothers' aeroplanes—the Type A, first military flyer of 1909, and the Type E, single-propelled pusher biplane of 1913. Modeled by Roderic Davis of Takoma Park, Md. (N.A.M. 815, purchase).

ROGALLO, FRANCIS M., Langley Field, Va.: Three examples of flexible-surfaced kites, invented by him (N.A.M. 834).

SPERRY GYROSCOPE COMPANY, Great Neck, N. Y.: An operable demonstration unit of the Sperry Automatic Pilot, assembled in an exhibition case with the original instrument of this type used by Wiley Post in his solo flight around the world, July 13 to 22, 1933 (N.A.M. 832).

SWALLOW AIRPLANE CO., INC., Wichita, Kans., through Sam Bloomfield, president: Fuselage of the Laird "Super Solution" biplane in which Maj. James H. Doolittle won the Bendix Race at the National Air Races and set a record of 11 hours 16 minutes elapsed time between Burbank, Calif., and Newark, N. J., September 1931 (N.A.M. 788).

UNITED AIRCRAFT CORP., East Hartford, Conn.: A utensil carried on the balloon "Graphic" during a trip from New York to Canaan, Conn., 1873 (N.A.M. 783).

UNIVERSITY OF DETROIT, Detroit, Mich.: A Packard Diesel aircraft engine of 1929, No. DR-980, Serial No. 5J, 9-cylinder, radial, air-cooled, developing 225 hp. at 1,950 r. p. m. (N.A.M. 818).

VEEDER-ROOT, INC., Hartford, Conn.: A Veeder Counter, similar to the one installed by the Wright brothers on their Kitty Hawk Flyer to record the revolutions of their engine when they made the first powered and controlled heavier-than-air flights by man, December 17, 1903 (N.A.M. 784).

WAGONROD, W. E., Dayton, Ohio: Two scale exhibition models, 1:16, of Wright brothers' aircraft—their glider of 1902 and their third aeroplane, 1905. Modeled by Joseph Fallo of Dayton (N.A.M. 792, purchase).

Respectfully submitted.

PAUL E. GARBER, *Head Curator.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the National Zoological Park

SIR: Transmitted herewith is a report on the operations of the National Zoological Park for the fiscal year ended June 30, 1954.

This year showed a considerable increase over last in accessions to the Zoo. In all, 899 accessions, comprising 2,250 individual animals, were added to the collection during the year by gifts, deposits, purchases, exchanges, births, and hatchings. Among these were many rare specimens never before shown in this Zoo. The addition of new kinds of animals enhances the value of the collection, which is maintained not only for exhibition but also for research and education, thus fostering the Smithsonian's established purpose of "the increase and diffusion of knowledge." Opportunities for research are afforded students of biology, particularly vertebrate zoology, as well as artists, photographers, and writers. Methods of study that do not endanger the welfare of animals or the safety of the public are encouraged.

In addition to the regular diversified duties of carrying on all the operations of the Zoo, the services of the staff included answering in person or by phone, mail, or telegraph questions regarding animals and their care and transportation; furnishing to other zoos and other agencies, public and private, information regarding structures for housing animals; cooperating with other agencies of Federal, State, and municipal governments in research work; and preparing manuscripts for publication.

The stone restaurant building, which was constructed in the Park in 1940, is leased at $46,212 a year. This money is deposited in the United States Treasury. The concessionaire serves meals and light refreshments and sells souvenirs.

THE EXHIBITS

Animals for exhibition are acquired by gift, deposit, purchase, exchange, birth, and hatching, and are removed by death, exchange, or return of those on deposit. Although depositors are at liberty to remove their specimens, many leave them permanently.

As in any colony of living things, there is a steady turnover, and the exhibits are constantly changing. Thus, the inventory of specimens in the collection on June 30 of each year does not show all the kinds of animals that were exhibited during the year, for sometimes creatures of outstanding interest at the time they were shown are no longer in the collection at the time the inventory is made.

The United States National Museum is given first choice of all ani-

mals that die in the Zoo. If they are not desired for the Museum they are then made available to other institutions or scientific workers. Thus the value of the specimen continues long after it is dead.

ACCESSIONS

GIFTS AND DEPOSITS

The Zoo has been particularly fortunate in having friends who show their sincere interest by bringing in specimens or arranging for acquisitions from foreign countries.

The Zoo's effort of several years to obtain specimens of sea otters (*Enhydra lutris*) was finally rewarded by the receipt on June 14, 1954, of three of these animals. They had been captured in the Aleutian Islands, Alaska, by the Fish and Wildlife Service of the Department of the Interior and transported from Alaska to Seattle by the U. S. Navy. They are of considerable interest historically as well as biologically, for it was the pursuit of sea otters by the Russians that led to much of the exploration of the Alaskan coast. Through excessive slaughter the animals were brought to the verge of extermination, and for some years it was thought that they might become extinct; but finally they began showing a slight increase in the wild. The Fish and Wildlife Service is now carrying on studies of sea otters to determine what steps should be taken to care properly for the wild ones and whether they can be successfully kept in captivity. In view of the rarity and great value of these animals, the Zoo's specimens were installed in cages that were air-conditioned to provide an environment as nearly like their natural habitat as possible, and they were fed in accordance with the suggestions of the Fish and Wildlife scientists. Unfortunately, however, the otters survived only a few days.

An outstanding acquisition of the year was a tuatara (*Sphenodon punctatum*) from the Government of New Zealand. This reptile, lizardlike in form, but having some characteristics of the turtle, is a primitive type that in its early stages of development possesses four or three eyes, but in the adult form has only two, which are large and brilliant. It has been called a living fossil because it appears to be the least changed of any animal from its ancient ancestors, which lived during the time of the dinosaurs. These animals have become scarce and are now rigidly protected by the Government, and so the specimen sent to the Zoo is a prized accession; special pains are being taken to provide for it suitable living conditions. As the tuatara normally lives in temperatures that are lower than those favored by lizards, and definitely lower than those prevailing in Washington in summer, it is necessary to cool the bottom portion of its cage in very warm weather. To induce it to eat freely, it has been given a lizard companion.



Philippine macaque (*Macaca philippinensis*), a recent accession in the National Zoological Park. (Photograph by Ernest P. Walker.)



Giant armadillo (*Priodontes gigantea*), the largest of living armadillos, and rare in collections. (Photograph by Ernest P. Walker.)



Upper figure, an Australian bearded lizard (*Amphibolurus barbatus*). Lower figure, New Zealand tuatara (*Sphenodon punctata*), a lizardlike reptile of ancient lineage that is now extremely rare. (Photograph by Ernest P. Walker.)



Three-horned chameleon (*Chamaeleon jacksoni*), a remarkable creature in that some individuals of the species have three horns, some have only two, and some have none. (Photograph by Ernest P. Walker.)

Two common Philippine macaques were received from the U. S. Air Force through Col. Leon Booth, Air Research and Development Command. These monkeys are of uncommon interest because they were used in an experiment at Halloman Air Force base, Alamagordo, N. Mex., where they were placed in an Air Force Aerobee rocket which was fired to an altitude of 200,000 feet. So far as known, these are the first primates to reach so great an altitude.

Laboratory mice were also used in this experiment. When the rocket took off, the animals were subjected to about 15 G's, a strain about 15 times that which is normal for their weight. Later in the flight they lost all weight, as they were away from the gravitational force of the earth.

A fine young chimpanzee (*Pan troglodytes*) was given to the Zoo by the Walter Reed Army Medical Center.

Through Lt. Col. Robert Traub, chief, Department of Entomology, Army Medical Service Graduate School, Army Medical Center, Washington, D. C., there were received three separate collections of mammals from Borneo and the Malay Peninsula, including a young wau-wau gibbon (*Hylobates moloch*), a crab-eating macaque (*Macaca irus*), two brush-tailed porcupines (*Trichys lipura*), a ferret badger (*Helictis everetti*), three Kinabalu tree shrews (*Tupaia montana baluensis*), two Rajah tree rats (*Rattus rajah*), four slow lorises (*Nycticebus coucang*), five specimens of three different species of the beautiful tree squirrels (*Callosciurus*), one pencil-tailed tree mouse (*Chiropodomys gliroides*), one big black Kinabalu tree rat (*Rattus infraluteus*), four specimens of Berdmore's squirrel (*Menetes berdmorei*), three spiny-backed tree rats (*Rattus sabanus*), and three Whitehead's tree rats (*Rattus whiteheadi*). The Berdmore's squirrels and one of the *Callosciurus* were collected by the United States Operations Mission to Thailand. The remainder of the specimens were collected by special United States Army Research Medical Units in Malaya and Borneo with the assistance of Capts. H. T. Newson and Bryce Walton.

President Syngman Rhee of Korea presented to President Eisenhower two Korean bear cubs (*Selenarctos thibetanus ussuricus*) that had been his pets. They were turned over to the Zoo where they are thriving and are an interesting and entertaining exhibit. They were flown to Washington by Northwest Airlines' Stratocruiser, in charge of Capt. Y. C. Kwak.

The Sun Life Insurance Co. of America, through Harvey L. Kesmodel, Jr., presented two young Malayan sun bears (*Helarctos malayanus*) the first the Zoo has had for some time, and a young Himalayan bear (*Selenarctos thibetanus*).

Dr. R. E. Kuntz, United States Medical Officer, Research Unit No. 3, Cairo, Egypt, sent a shipment of 22 kinds of lizards and snakes,

comprising 125 specimens. These are especially interesting as some of them are highly specialized for life under desert conditions.

Shrum's Chinchilla Ranch, of Front Royal, Va., presented a male chinchilla, and the Greeson Chinchilla Farm, of Arlington, Va., deposited in the Zoo for a short time four chinchillas (*Chinchilla chinchilla*), a pair and their two young. These attractive little creatures formed an interesting exhibit.

Through the interest of Mrs. Esther Van Wagoner Tufty, the Government of Australia and U. S. Consul General Donald Smith presented a pair of great gray kangaroos (*Macropus giganteus*).

The Hecht Co. of Washington presented 15 young monkeys representing 6 different kinds. These had been on exhibition in the Hecht Co. store windows and were desirable additions to the Zoo collection.

The Wyoming Game and Fish Commission, through the kindness of State Game Warden Norbert C. Faass, sent two pronghorn antelopes (*Antilocapra americana*), the first the zoo has had for many years.

Robert W. Macdonald, of the National Marine Bank Building, Baltimore, Md., acting on behalf of the people of the Republic of Indonesia, presented a Malayan sun bear (*Helarctos malayanus*). The Isthmian Steamship Co. brought the bear to the States.

The New York Zoological Society, through James Oliver, gave 10 arrow-poison frogs (*Dendrobates auratus*) and 10 of the very beautiful yellow atelopus frogs (*Atelopus varius zeteki*). The arrow-poison frogs are particularly interesting, as the secretion from their backs is used by the Central American natives to poison the tips of their blowgun darts.

Joe Walkup, of the Safeway Stores at Landover, Md., gave the Zoo a very beautifully marked necklace snake (*Erythrolamprus aesculapii*) that he had found in food material received from the Tropics.

Mario DePrato, principal keeper in the National Zoological Park, gave to the Zoo 10 different kinds of small creatures that he obtained on his vacation. Especially interesting were the narrow-mouthed toads (*Microhyla carolinense*) not previously exhibited.

With the growth of the Washington metropolitan region there has been a constant increase in the number of helpless local wild creatures rescued by kind people and brought to the Zoo. Some of those that seem to have a fair chance of survival are liberated, some are exchanged for material needed for the Zoo, and occasionally some are given to persons who will give them good care. During the past year 127 Peking ducks, 71 rabbits, 40 opossums, 33 hamsters, 13 gray squirrels, 12 skunks, 6 robins, and various other creatures that had been pets, or were found when young or injured, were turned over to the Zoo. This gives unduly large accession and removal lists, but to re-

ceive, care for, and place such creatures appears to be a proper function of the National Zoological Park.

This year, as in many years past, various individuals have deposited in the Zoo animals to which they desired to retain title. These are most acceptable additions to the exhibits. Depositors are assured that the animals will receive routine care, but the Zoo assumes no responsibility for their return and no obligation to replace any that do not survive.

DEPOSITORS AND DONORS AND THEIR GIFTS

(Deposits are marked *; unless otherwise indicated, addresses of donors are Washington, D. C.)

Abrahams, Jennifer, Arlington, Va., cottontail rabbit.
Ackner, Ned E., Arlington, Va., 2 Peking ducks.
Adams, Charles, indigo snake.
Akins, K., Indian Head, Md., painted turtle.
Alenstein, Mrs. Charles, Peking duck.
All, Robert E., Fairfax, Va., domestic rabbit.
American Airlines, Inc., through Herb Ford, 18 zebra finches, 20 Gouldian finches.
Ammerman, J. F., Arlington, Va., red-lined turtle.
Angel, Mrs. Jane, horned lizard.
Archbold, Mrs. Anne, whippoorwill.
Army Medical Center, Walter Reed, chimpanzee.
Army Medical Service Graduate School, through Col. Robert Traub, 3 Kinabalu tree shrews, 2 Rajah tree rats, 2 slow lorises, 5 Siamese squirrels, pencil-tailed tree mouse, Kinabalu tree rat, 4 Berdmore's squirrels, 2 Bornean orangutans, wau-wau gibbon, crab-eating macaque, 2 brush-tailed porcupines, ferret badger, 2 slow lorises*, 3 spiny-backed tree rats *, 3 Whitehead's tree rats.*
Ashton, Mrs. A., 2 domestic rabbits.
Ault, Richard, red-bellied turtle
Australia, Commonwealth of, and Consul General Donald Smith, Sydney, Australia, through Mrs. Esther Van W. Tufty, 2 gray kangaroos.
Avery, Phyllis, grass parakeet.
Ayer, Bruce, 2 domestic rabbits.
Babcock, Mrs. Stover, Silver Spring, Md., rhesus monkey.
Backer, J. E., Silver Spring, Md., alligator.
Badger, Mrs. June, Middleburg, Va., 5 pygmy sunfish, 5 American flagfish, 11 mosquitofish, 1 "Mad Tom" catfish, 2 bluefin top minnows, 2 wild mollies.
Bailey, Capt. R. W., Camp Lejeune, N. C., white-tailed deer.
Baldi, Fiorenza, caiman.
Baldwin, Robert, Silver Spring, Md., spotted salamander.
Barnes, Clayton, great horned owl.
Barrett, David M., Alexandria, Va., golden hamster.
Barto, Mrs. W. F., Arlington, Va., cowbird.
Battenberg, Mrs. William R., Vienna, Va., Peking duck.
Baxter, Frank A., domestic rabbit.
Baylor, Mrs. C. Neill, Jr., Takoma Park, Md., Peking duck.
Becker, H. E., Takoma Park, Md., pilot black snake.
Beers, Lynn, 2 red squirrels.
Bell, Wayne A., Arlington, Va., fish hawk.
Bennett, Mrs., Bethesda, Md., black widow spider.
Bennett, Harry M., Morningside, Md., raccoon.
Benton, Robert, Winston-Salem, N. C., chain or king snake.
Bergan, M. P., Arlington, Va., rabbit, caiman, horned lizard.
Bernstein, Mrs., A., Peking duck.*
Bernstein, Mrs. Howard, Chevy Chase, Md., domestic rabbit.
Bevis, Mrs. Kathryn, 2 Peking ducks.
Bittenbender, Karl, Arlington, Va., cardinal.
Bomar, Edward, Central American boa.
Bonnette, Lynn, Silver Spring, Md., Peking duck.
Booher, Joseph, McLean, Va., rhesus monkey.*
Boone, Emmette, Alexandria, Va., raccoon.
Bowsel, Helen W., robin.
Bradburd, Eddie, Silver Spring, Md., 2 opossums.
Breen, Mrs. G. H., domestic rabbit.
Breitel, Linda, domestic rabbit.
Briggs, Mrs. L. E., Kenwood, Md., spectacled caiman.
Brisker, Mrs. N., hamster.
Brodell, Mrs. F., Chevy Chase, Md., Peking duck.
Brolda, Arthur, Alexandria, Va., cedar waxwing.

Brown, Sidney, smooth-scaled green snake.
Brown, Mr. and Mrs. W. S., Kensington, Md., mole.
Brucker, Brad, Arlington, Va., 4 water snakes.*
Bucher, Rose, Takoma Park, Md., Peking duck.
Buck, Larry, Arlington, Va., 4 box turtles.
Burch, E., Hyattsville, Md., Peking duck.
Burke, Mrs. Thomas J., Arlington, Va., brown capuchin.
Burkech, Agie, opossum.
Burris, Robert E., Florida water turtle.
Bushee, Charles A., Salisbury, Md., 3 squirrel monkeys, woolly monkey,* capuchin.
Byrd, G. C., guinea pig.
Capps, G. B., domestic rabbit.
Carey, Otis F., African guenon.
Carnicero, J., 3 Peking ducks.
Carroll, S. H., Takoma Park, Md., 2 domestic rabbits.
Carter, Dr. Hill, red fox.
Chamberlain, Mary, red-lined turtle.
Chapman, S. H., kinkajou.*
Chase, Joe, Franklin, Va., box turtle, indigo snake, black racer, water snake.
Chasy, Paul S., Arlington, Va., caiman.
Chatelaine, Mrs. Irene, York, Pa., macaw.*
Cherney, Chris, Arlington, Va., pied-billed grebe.
Clanahan, Lee W., 2 kingbirds.
Clark, Ronald W., Riverdale, Md., pigeon.
Cleer, Robert C., Falls Church, Va., brown capuchin monkey.
Clymer, Frank, Arlington, Va., black rabbit.
Cohen, Richard, Alexandria, Va., caiman.
Cole, Edgar T., 2 Peking ducks.
Collinge, Mrs. S., Bethesda, Md., domestic rabbit.
Compton, Mrs. Annette, 2 red-lined turtles.
Connor, Ralph R., albino opossum.
Conroy, Mike, Silver Spring, Md., water snake.
Cooper, Mrs. Henry O., Upper Marlboro, Md., 2 opossums.
Coopersmith, Joseph, false chameleon.
Corman, Harold, and Eisenberg, Jack, great blue heron.
Cortes, Mrs. J., Riverdale, Md., 2 alligators.
Cox, David, McLean, Va., 2 woodchucks.
Cranford, Dick, domestic rabbit.
Crawford, C. W., 2 rabbits.
Crymes, C. L., domestic rabbit.
Curtin, William, Alexandria, Va., domestic goose.
Dailey, Kay, 2 eastern skunks.
Daniel, James, Vienna, Va., pied-billed grebe.
Dantzic, Dr. S. Oliver, Silver Spring, Md., Peking duck.
Davis, Marge Anne, Silver Spring, Md., raccoon.
Davis, Robert R., kinkajou.*
Day, Hugh A., IV, Beltsville, Md., 2 opossums.
Day, Mrs. Walter O., Falls Church, Va., robin.
DeAgro, Richard P., caiman.
Deahl, M. D., Arlington, Va., opossum, 2 golden hamsters.
Deane, Mrs. Helen C., Hyattsville, Md., woolly monkey.
Delafield, D. A., Takoma Park, Md., 2 parakeets*
DeLaureal, H. H., Arlington, Va., 2 Peking ducks.
Del Genio, Mrs. N., Peking duck.
DeMint, Miss Joyce, robin.
DePrato, Joe and Jack, Langley Park, Va., 35 toads.
DePrato, Mario, Lanham, Md., anolis, 6 hermit crabs, 6 fiddler crabs, 4 stone crabs, 2 brown skinks, 2 narrow-mouth toads, newt, spotted salamander, 6 small Florida toads, 3 large South Carolina grasshoppers, 5 giant Florida grasshoppers.
Detwiler, David, chukar quail.
DeWilde, Austin, Chevy Chase, Md., 2 Peking ducks.
Dews, J. M., opossum.
Dillon, Mrs. Gay, Falls Church, Va., barred owl.
Dix, Michael, robin, 3 pilot black snakes, water snake.
Donnelly, John, rabbit.
Donohue, Joseph D., Silver Spring, Md., domestic rabbit.
Dove, Mrs. F. A. G., Woodacres, Md., 4 white mice.
Dove, Leo B., Peking duck.
Downey, Mike O., spectacled caiman.
Droughman, Mrs. Diane, Java finch.
Dudley, Donnie, guinea pig.*
Dudley, Mrs. T. E., domestic rabbit.
Dunn, Louis C., eastern skunk.
Edwards, M. W., opossum.
Eleazer, Dr. J. M., Clemson, S. C., red-shouldered hawk.
Eleazer, Thomas, Clemson, S. C., turkey buzzard.
Eller, Arnold, Falls Church, Va., 2 Peking ducks.
Ellis, Julia D., mourning dove.
Embree, Effingham, Vienna, Va., 2 white goats,* 5 domestic goats.
Etherson, Richard, Silver Spring, Md., caiman.
Fabrizio, Francis J., 2 Peking ducks.
Fahey, John, Takoma Park, Md., gopher tortoise.
Faulkner, John D., Bethesda, Md., domestic rabbit.

Fauntleroy, Robert, snapping turtle.
Feeney, Joseph, Chevy Chase, Md., domestic rabbit.
Ferris, Gordon, H., Hyattsville, Md., pied-billed grebe.
Fieser, Jim and John, Bethesda, Md., 2 horned lizards.
Finley, Susan, Alexandria, Va., 2 Peking ducks.
Fire Department, National Airport, fish hawk.
Fish and Wildlife Service, U. S., Anchorage, Alaska, 3 sea otters.
Through Robert H. Bain, Cambridge, Md., 9 Canada geese.
Through Howard W. Brown, Lexington Park, Md., 3 whistling swans.
Through Dr. Herbert Graham, Chief, North Atlantic Fisheries Investigation, Woods Hole, Mass., electric eel.
Fisher, Mrs. J., Alexandria, Va., Peking duck.
Fisher, Judy, Alexander, Va., Peking duck.
Fisher, Robert, Kensington, Md., black raccoon.
Flocken, Jed, domestic rabbit.
Flood, Rickey, domestic rabbit.
Food and Drug Administration, U. S., through Dr. Curtis, 4 macaques.
Ford, Bertelle E., Rockville, Md., pilot snake, 3 iguanas,* 2 African lions,* brown capuchin.*
Frank, Glynn N., Hyattsville, Md., copperhead snake.
Franklin, Lloyd, Lanham, Md., woodchuck.
Frazier, Mrs. Ann, opossum.
Freedman, Herbert, 2 worm snakes.
Freeman, Carl, Silver Spring, Md., 3 Peking ducks.
Freeman, Lee, gray squirrel.
French, J. G., Sharon Hill, Pa., 2 sooty mangabeys.*
Frese, Martha and Wayne, Chevy Chase, Md., white rabbit, guinea pig.
Frost, Linda E., canvasback duck.
Frye, Charles, guinea pig.
Funkhouser, Kathleen, Arlington, Va., 2 Peking ducks.
Garrison, Beau, Hollywood Md., red-shouldered hawk.
Garrison, D., Silver Spring, Md., 2 Peking ducks.
Gauch, Hugh, Bowie, Md., caiman.
Gauntlett, M., pigeon.
Gavell, Mrs. Vivian, domestic pigeon.
Gaver, Gordon, Thurmont, Md., 6 alligators,* 3 black tegus,* rhesus monkey.*
Gaw, Donald and Richard, Arlington, Va., Peking duck.
Gentle, Fred, Arlington, Va., queen snake.
Glaser, Philip E., Falls Church, Va., caiman.
Godman, Herman, 2 red-lined turtles.
Goodman, George, Alexandria, Va., opossum.
Graves, Donald, domestic rabbit.
Greenwood, Walter and Tommy, Falls Church, Va., musk turtle, snapping turtle.
Greenwood, W. B., Falls Church, Va., caiman.
Greeson Chinchilla Farm, Arlington, Va., 4 chinchillas.*
Griggs, Nelson M., Wheaton, Md., chain or king snake.
Groomes, Warren L., Silver Spring, Md., Peking duck.
Gunn, Mrs. Dorothy, Hyattsville, Md., 9 canaries.
Hahl, Mrs. L., 2 grass parakeets.
Haines, Earl, Frederick, Md., spider monkey.
Hall, Mrs. James, Silver Spring, Md., Peking duck.
Haller, H. L., opossum.*
Hambleton, James, Takoma Park, Md., timber rattlesnake.
Hamilton, Mrs. George E., College Park, Md., spider monkey.
Hanna, Mrs. W. H., Alexandria, Va., domestic rabbit.
Hansen, Keith L., Gainesville, Fla., 2 frogs.
Hardesty, M. N., skunk.
Harris, Wilson, Jr., Charles, and Scotty, Falls Church, Va., white-tailed deer.
Harvin, Mrs. M. D., Arlington, Va., 5 mallard ducks.
Hawks, Alfred L., Triangle, Va., 2 copperhead snakes.
Hay, Malcolm, box turtle.
Hayhoe, Walter, 2 raccoons.
Hays, Dallas B., Bethesda, Md., 2 Peking ducks.
Hays, Jonathan, caiman.
Hazlett, Brian, District Heights, Md., Florida water turtle.
Hecht Co., 3 rhesus monkeys, 4 green guenons, 2 golden or dog-faced baboons, 2 spider monkeys, 2 sooty mangabeys, 2 brown capuchins.
Hennessy, Mrs. J. D., Arlington, Va., caiman.
Herber, W., Takoma Park, Md., blue jay.
Hermann, Fredericka and Sabina, 2 caimans.
Herndon, G. O., Chevy Chase, Md., domestic rabbit.*
Hickman, John R., Silver Spring, Md., 2 Peking ducks.
Higgins, Juanita and Thelma, 3 guinea pigs.
Hindman, Harold, Alexandria, Va., domestic rabbit.
Hines, William George, Jr., alligator.
Hinman, W. S., Falls Church, Va., flying squirrel.
Hitt, Albert, Hyattsville, Md., woodchuck.

Hoffman, J. L., Woodacres, Md., Peking duck.
Hoffner, Sandra, killdeer.
Hogle Zoo, Salt Lake City, Utah, western racer snake, 2 western rattlesnakes, Great Basin rattlesnake, banded king snake.
Holeran, Mrs. Marie, Fairfax, Va., ringnecked dove.
Holt, Phil, Bethesda, Md., horned lizard.
Hope, Mrs. P. B., Alexandria, Va., 3 Cumberland turtles.
Hopkins, Thomas M., Laurel, Md., 2 gopher turtles.
Horn, Stefan F., mockingbird.
Howarth, A. E. R., Arlington, Va., Peking duck.
Howe, E. H., Falls Church, Va., skunk.
Howell, R. D., Peking duck.
Huddle, Jesse, Arlington, Va., brown capuchin.
Huggins, Stephen and James, Arlington, Va., bantam rooster.
Hulen, Mrs. Clarence, Falls Church, Va., 2 Peking ducks.
Huntt, Mrs. H. S., Silver Spring, Md., 2 domestic chickens.
Hutchison, A. Scott, domestic rabbit.
Hynek, Frank, emperor boa, night snake.
Ingham, Mrs. Lulu M., Arlington, Va., red-lined turtle.
Jameson, Louis, 9 guinea pigs.
Jaquette, Jean P., Arlington, Va., robin.
Jay, LeRoy, black-widow spider.
Jenary, William F., Hillcrest, Md., screech owl.
Jenkins, Mrs. Florence, Arlington, Va., gray squirrel.
Jenks, Robert H., Chevy Chase, Md., coach whip snake, 3 soft-shelled turtles, chicken snake, mud turtle.
Jennings, John F., Friendly, Md., 2 raccoons.
Jennings, Michael, guinea pig.
Johnson, Carl H., Jr., Silver Spring, Md., fish hawk.
Johnson, D. C., Arlington, Va., 7 DeKay's snakes.
Johnson, Harry W., Rockville, Md., 2 Peking ducks.
Johnson, John E., Falls Church, Va., Peking duck.
Johnson, Mrs. Johnnie G., skunk.
Johnson, Julius James, alligator.
Jones, Barbara, 2 domestic rabbits.
Jones, Mrs. E. W., 2 Peking ducks.
Jones, Roy K., 2 domestic rabbits.
Joseph, Mrs. Marion, ringtail monkey.*
Josko, Mrs. Eva, opossum.
Jouvenal, Mrs. Hannah A., Silver Spring, Md., American bittern.
Kaplan, Melvin, 2 Peking ducks.
Keese, William E., Jr., gray squirrel.
Keith, Mrs. L. W., 2 false chameleons.
Kerr, Dr. L. E., 3 Peking ducks.
Killinger, George, domestic rabbit.
Kirsch, Dale L., skunk.
Kittelle, John, Arlington, Va., 2 grass parakeets.
Klein, Mrs. Elmer, 2 gray squirrels.
Kokker, Mrs. G. K., Silver Spring, Md., domestic rabbit.
Koppy, L., Portland, Oreg., 14 Pacific Northwest rattlesnakes.
Koval, Thomas, Cheverly, Md., caiman.
Krehdiel, Peter, Falls Church, Va., ringnecked dove.
Kulp, Frank P., Silver Spring, Md., pilot black snake.
Kuntz, Dr. Robert E., Cairo, Egypt, black-necked spitting cobra, 4 horned vipers, cat-eyed snake, 18 sand vipers, Egyptian cobra, 3 Thebes sand boas, 3 Dassas sand boas, 7 sand snakes (three species), 3 Gidari snakes, 3 diadem colubers, 3 big-eyed snakes (2 species), gecko, 2 chameleons, 20 skinks, 30 sand lizards, 24 sand skinks, 3 five-lined skinks, 3 *Acanthodactylus* lizards.
Lafever, Donald, Herndon, Va., copperhead snake.
Lamb, Terry, 2 red foxes.
Laney, Melvin J., Silver Spring, Md., crow.
Latta, Carolyn, Mount Rainier, Md., domestic rabbit.
Lawrence, Betty, English sparrow.
Lee, Carol M., Silver Spring, Md., Peking duck.
Lee, Mrs. Edward, Silver Spring, Md., 4 guinea pigs.
LeGost, Frank C., Arlington, Va., raccoon.
Lenderking, Robert G., Bethesda, Md., gray squirrel.
Letner, A. E., 8 canaries.
Letner, G. E., 7 canaries.
Letterkenny Ordnance Depot, Chambersburg, Pa., 4 ground hogs.
Lever, Michael, 2 guinea pigs.
Lewis, Millard, 2 Peking ducks.
Lienau, Mrs. C. W., Silver Spring, Md., Peking duck.
Ligon, J. Stokley, Carlsbad, N. Mex., 2 Gambel's quail × scaled quail hybrids.
Livermore, Mrs. Gordon, Arlington, Va., 4 Peking ducks.
Locke, Otto Martin, New Braunfels, Tex., 3 rattlesnakes, bull snake, striped racer, 6 Mexican water moccasins, horned lizard.
Loftis, J. R., domestic rabbit.
Logan, Wilton, Bethesda, Md., domestic rabbit.
Loomis, Ormond E., Alexandria, Va., 11 opossums.
Lowe, James M., Jr., Cabin John, Md., Peking duck.
Lynch, Joseph F., 2 domestic rabbits.
Lynott, William, Hyattsville, Md., Peking duck.

Macdonald, Robert W., Baltimore, Md., for the people of Indonesia, Malayan sun bear.
Machlin, Jack, Arlington, Va., Peking duck.
Maggenti, R. J., Chillum, Md., Peking duck.
Magnuson, Hon. Warren G., 4 Cumberland turtles,* Barbour's turtle.*
Mallinof, Mrs. P. Greenbelt, Md., blue jay.
Malone, Jane, Arlington, Va., alligator.
Marley, Miriam, Arlington, Va., alligator.
Marshall, Leonard M., 5 woodchucks.
Mason, Mrs. Blanche, 2 Peking ducks.
Matson, Bill, Silver Spring, Md., alligator.
Matter, John M., Arlington, Va., Peking duck.
Matthews, Mrs. J. B., Alexandria, Va., Peking duck.
Maurice, Winthrop, Peking duck.
McArtor, Mike and Betty, opossum.
McCabe, John H., Arlington, Va., gyrfalcon.*
McClanahan, T. E., caiman.
McClellan, Billy, Silver Spring, Md., Peking duck.
McCollum, W. V., University Park, Md., 2 Peking ducks.
McDaniel, Barbara, skunk.
McDonald, Erling, Takoma Park, Md., Pacific rattlesnake.*
McGee, Henry, broad-winged hawk.
McGowan, Mrs. Richard, Bethesda, Md., 8 grass parakeets.
McWilliams, Mrs. W. C., Arlington, Va., grass parakeet.
Merritt, Philip, cockatiel.
Meryman, Dr. Harold T., Cabin John, Md., 3 copperhead snakes.
Mesnig, Mrs. George E., Alexandria, Va., gray squirrel.
Mickey, Paul, domestic rabbit.
Miller, George, spectacled caiman.
Miller, J. C., Falls Church, Va., 5 young rabbits.
Mills, Joseph M., woodchuck.
Monagan, Cathy, mourning dove.
Montgomery, C. R., Sarasota, Fla., 12 small anacondas, indigo snake, large anaconda,* ball python.*
Moore, Mrs. George, Glenn Dale, Md., skunk.
Morgan, David, G., Bethesda, Md., loggerhead shrike.
Morse, Alfred W., Arlington, Va., domestic rabbit.
Mount Rainier Fire Department, Mount Rainier, Md., ground hog.
Mumaw, Homer, Harrisonburg, Va., 5 red foxes.
Nalbandian, Richard, gray squirrel.
National Institutes of Health, Bethesda, Md., through Mr. Polley, 3 white-footed mice, 3 Egyptian spiny mice, 2 rice rats.
National Park Service, Great Falls, Md., copperhead snake.
Neale, A. W., marine turtle.
Nelson, G. G., golden pheasant.
New York Zoological Society, New York, N. Y., through James Oliver, 10 arrow-poison frogs, 10 yellow atelopus frogs.
New Zealand, Government of, tuatara.
Nichols, George, Belgian rabbit.
Norman, L. E., Hyattsville, Md., 3 horned lizards.
Norris, Hubert, College Park, Md., caiman.
North Atlantic Chemical & Fertilizer Co., New York, N. Y., Indian python,* 4 regal pythons,* 2 Indian pythons.*
O'Brien, P. G., Silver Spring, Md., 3 canaries.
O'Connor, Elizabeth, Chevy Chase, Md., domestic rabbit.
Ohly, Nicky, McLean, Va., 2 water snakes, pilot snake.
O'Neal, David, brown capuchin monkey.
Owens, Harry C., domestic rabbit.
Packwood, Norval E., Falls Church, Va., white-faced capuchin.
Palmer, Mrs. Marian E., squirrel.
Parker, Terry, Arlington, Va., Peking duck.
Parks, Mrs. E. N., Silver Spring, Md., Peking duck.
Patterson, Perry, Jr., Sandy Spring, Md., woodchuck.
Paul, D. M., Falls Church, Va., 4 Peking ducks.
Pena-Briceno, Capt. Enrique, troupial.
Peter, Mrs. Alexander, Kensington, Md., slate-colored junco.
Petroff, Mrs. G., hamster.
Phillips, Walter M., Frederick, Md., screech owl.
Pielmeier, George, Japanese black bear.
Piper boys, domestic rabbit.
Poe, Tommy, Arlington, Va., 2 Peking ducks.
Porter, Mary, sparrow hawk.
Poundstone, Mrs. F. M., Silver Spring, Md., 2 Peking ducks.
Pratt, Mr. and Mrs. E. Lee, Branchville, Md., 2 Barbary apes.
Preacher, Stephen, Arlington, Va., 2 chickens, 2 Peking ducks.
Price, C. M., Arlington, Va., caiman.
Price, Forst E., Alexandria, Va., caiman.
Price, Jeffrey, Chevy Chase, Md., horned lizard.
Propes, Thomas C., 2 Peking ducks.
Prophet, Beverly, Wheaton, Md., 2 Peking ducks.

Pulsifer, Clyde R., bantam fowl.
Pumphrey, Don, Bladensburg, Md., matamata turtle, alligator.*
Purnell, L. E., Arlington, Va., domestic rabbit.
Quinter, Ralph, Chevy Chase, Md., horned lizard.
Reed, Laury, Kensington, Md., Peking duck.
Reinhardt, Roger Edward, white-throated capuchin monkey.
Remillard, Roger, opossum.
Renshaw, E. F., Alexandria, Va., 2 Peking ducks.
Resnick, Jerry, king snake.
Rettig, Florence, caiman.
Reudiger, Mrs. Stephen, 8 golden hamsters.
Reynolds, Mrs. S. W., Bethesda, Md., 2 Peking ducks.
Rhee, President Syngman, Seoul, Korea, 2 Korean bears.
Rice, John, and Ruotsi, Otto, through Hon. John B. Bennett, Hancock, Mich., bald eagle.
Richardson, D. W., Bethesda, Md., domestic rabbit.
Richardson, Jeanette, Peking duck.
Richbourg, Philip G., Mount Rainier, Md., albino squirrel.
Ringer, Joyce Brookmont, Md., domestic rabbit.
Risley, Michael, Florida king snake.
Rivero. Dr. J. S., Mayagüez, Puerto Rico, Puerto Rican boa.
Robbins, Larry, Silver Spring, Md., water snake.
Robbins, Mrs. Leroy, opossum.
Robey, J. E., Takoma Park, Md., Peking duck.
Rollman, A. G., Riverdale, Md., 2 Peking ducks.
Roper, George S., opossum.
Rose, Paul, domestic rabbit.
Rueger, L. J., Silver Spring, Md., Peking duck.
Russell, Earl, 2 barn owls.
Sabine, L. D., Bethesda, Md., caiman.
Sapienza, Basil, Takoma Park, Md., domestic rabbit.
Sarkin, H. T., mallard duck.
Saunders, William R., caiman.
Sawyers, Thomas R., Alexandria, Va., rhesus monkey.
Scallorn, Nicholas and Dean, eastern swamp rabbit.
Scerbo, Mrs. W. M., guinea pig.
Schley, Mrs. J. L., opossum.
Schmid, Paul, Jr., 3 corn snakes*, king snake*, black rat snake*, 2 water snakes*, Central American boa*, western bull snake*, 2 black racers*, black snake*, ringneck snake*, 2 garter snakes*, 2 black racers.*
Scillian, Mrs. Glenn, Silver Spring, Md., Peking duck.
Scofield, John, Wheaton, Md., 2 blood-billed weavers, zebra finch, saffron finch.
Scott, Howell, scorpion.
Scully, Charles W., Jr., Alexandria, Va., Peking duck.
Sears, Eddie, Chevy Chase, Md., horned lizard.
Seligson, Stephen, Silver Spring, Md., wood thrush.
Shahan, Gary, Mount Rainier, Md., caiman.
Shannon, Nancy, Falls Church, Va., Peking duck.
Sharp, Hannah, domestic rabbit.
Shaw, John D., Bethesda, Md., barred owl.
Shaw, Mrs. Olen C., opossum.
Shaw, Mrs. Ralph D., Oxon Hill, Md., spider monkey.*
Shelton, Eddie, Brown, Frank, and Mills, Nancy, woodchuck.
Shillin, Eleanor, 4 goldfish, 4 snails.
Shilling, George, box turtle, grass snake.
Shipe, Mildred, Java finch.
Shoreham Pet Shop, Bethesda, Md., 20 golden hamsters, 75 white mice.
Shrum's Chinchilla Ranch, Front Royal, Va., chinchilla.
Siegel, Sharon and Howard, caiman.
Simmons, James, Arlington, Va., caiman.
Simms, William A., skunk.
Simpson, Janey, caiman.
Simpson, Joseph, Seat Pleasant, Md., squirrel monkey.
Smith, Maj. Hudgins R., Arlington, Va., Central American boa.
Smith, Jean O., hog-nosed snake, 48 leopard frogs.
Smith, Mrs. Lyle, Arlington, Va., Peking duck.
Smith, Roy, albino squirrel.
Smith, William T., College Park, Md., Muscovy duck.
Snell, Mrs. Dale, Chevy Chase, Md., black rabbit.
Sommers, Pete and Philip, Silver Spring, Md., domestic rabbit.
Sparks, Pete, Bladensburg, Md., 3 mynah birds.*
Sparks, R. M., Alexandria, Va., wood turtle.
Speiss, Katherine, 2 Peking ducks.
Spilman, Wilbur, Chevy Chase, Md., caiman.
Springfield, Randy, Arlington, Va., domestic rabbit.
Spruill, Larry, Bethesda, Md., opossum.
Stadler, Mrs. Paul, Silver Spring, Md., 2 Peking ducks.
Stahl, O. Glenn, Arlington, Va., Peking duck.
Stambaugh, D., 6 ring-necked doves.*
Stanley, A. D., domestic fowl.
Starkloff, H. W., Rockville, Md., Peking duck.

Stephens, Mrs. V. K., Chevy Chase, Md., 2 Peking ducks.
Stephenson, J. E., Alexandria, Va., Peking duck.
Sternbergh, Caribel, guinea pig.
Stevens, Mrs. Erland, Arlington, Va., horned toad.
Stevenson, Billy, Hyattsville, Md., hybrid duck.
Stone, G. K., 2 snapping turtles, 6 painted turtles, 6 mud turtles.
Stulta, Robert F., Woodstock, Va., great horned owl.
Sullivan, A. P., Arlington, Va., 2 Peking ducks.
Sun Life Insurance Company of America, Baltimore, Md., through Harvey L. Kesmodel, Jr., Himalayan bear, 2 Malayan sun bears.
Sweet, Mrs. Trevor W., Chevy Chase, Md., American goldfinch.
Symonds, M. E., Edinburg, Va., white-tailed deer.
Tackett, Mrs. A. H., opossum.
Tait, Mrs. DeSparre, paradise whydah finch.
Talbot County Humane Society, Easton, Md., bald eagle.
Taylor, C. S., Peking duck.
Taylor, E. W., yellow-bellied terrapin, Cumberland turtle.
Taylor, Lucile, Bethesda, Md., 13 opossums.
Teller, Robert W., Silver Spring, Md., horned lizard.
Thayer, Mrs. Mollie Van Renselaar, 15 yellow atelopus frogs, 6 blue honeycreepers.
Thomas, John P., Bluemont, Va., ring-necked snake.
Thotlin, Fred, Alexandria, Va., indigo snake.
Tiller, Mrs. B. C., Hyattsville, Md., alligator.
Tiller, Jeanne L., Cheverly, Md., bull frog.
Townsend, Judy, domestic rabbit.
Trefflich, Henry, New York, N. Y., 2 chimpanzees.*
Tremont, Henry, barred owl.
Tribble, Jack S., weeping capuchin.*
Tropical Garden Pet Shop, Richmond, Va., red coatimundi.
Tuyander, Harry, 3 cottontail rabbits.
Twigg, Susan, Alexandria, Va., 2 boa constrictors.*
Tyler, B. O., Gaithersburg, Md., gray squirrel.
Tyrrell, W. B., Takoma Park, Md., 4 pilot black snakes, 2 greater five-lined skinks.
Ulman, Mrs. Harry E., Laurel, Md., caiman.
U. S. Air Force, through Col. Leon Booth, 2 Philippine macaques.
University of Colorado Museum, Boulder, Colo., 2 western chipmunks.
Van Hoesen, Mrs. J. B., Silver Spring, Md., mockingbird.
Van Natter, F. M. robin.
Vazquez, Alberto W., Arlington, Va., chain or king snake*, Boyle's king snake*, pilot black snake.*
Vega, Jessie, domestic rabbit.
Vehrencamp, Mrs. W. L., Mount Jackson, Va., white-tailed deer.
Ver Standig, Belmont, white-throated capuchin monkey.
Voight, Jack, Bethesda, Md., caiman.
Wade, J. P., Peking duck.
Wager, Candy, Bethesda, Md., domestic rabbit.
Walker, Andree and Norman, Arlington Va., white rat.
Walkup, J. J., Landover, Md., 2 boa constrictors, necklace snake.
Wamsley, W. S., Falls Church, Va., wild rabbit.
Ward, Mrs. Bettina, Middleburg, Va., African gray parrot.*
Warner, Tony, Bethesda, Md., snapping turtle.
Warren, Mrs. F. C., Arlington, Va., eastern skunk.
Washington Missionary Collage, Takoma Park, Md., black racer, 2 pilot black snakes, 5 water snakes, 2 ring-necked snakes.
Weber, Elizabeth, horned lizard.
Weinberg, T. H., 1 black tetra, 2 kissing gouramies, 2 spotted gouramies, 1 zebra danio, 5 angel fish.
Weinraub, Bobby, Peking duck.
Weiss, Marc, Bethesda, Md., water snake.
Wesley, L. S., Spencerville, Md., pilot black snake, barn owl.
Wesley, Rhoda, Spencerville, Md., black snake.
Wetzel, William W., Fort Belvoir, Va., rhesus monkey.*
Wheaton, Hal D., Hill City Zoo, Rapid City, S. Dak., 4 diamond-backed rattlesnakes.
Wigent, John G., Arlington, Va., domestic goose.
Williams, H. J., Springfield, Va., Peking duck.
Williams, Lt. Col. L. O., Quantico, Va., caiman.
Williamson, Mrs. E. T., cardinal.
Winnacker, John, Chevy Chase, Md., spectacled caiman.
Witt, Bill, Arlington, Va., king snake*, black snake*, Holbrook's king snake*, southern pilot snake.*
Witter, Benjamin H., Brookmont, Md., opossum.
Wolf, John E., Arlington, Va., barn owl.
Wood, Julia, Shadyside, Md., king snake.

Woodward, Susan, Alexandria, Va., Peking duck.
Word, T./Sgt. Marguerite F., Arlington, Va., spectacled caiman.
Wright-Patterson Air Force Base, Ohio, through Capt. Reeves, 2 Philippine macaques.
Wright, Sondra, Mount Rainier, Md., domestic rabbit.
Wyoming Game and Fish Commission, through Game Warden Norbert C. Faass, Cheyenne, Wyo., 2 pronghorn antelopes.
Young, E. M., Alexandria, Va., 2 Peking ducks.
Zacchini, Silver Spring, Md., chimpanzee.*
Zuk, Ted, domestic rabbit.

PURCHASES

Among a number of interesting specimens obtained by purchase were:

The first giant armadillos (*Priodontes giganteus*) ever exhibited in the National Zoo. These are the largest of the living armadillos and have been exhibited in captivity only a few times.

The first golden-bellied mangabeys (*Cercocebus chrysogaster*) ever exhibited by the Zoo were obtained from the Belgian Congo.

A female lesser panda (*Ailurus fulgens*) was obtained as a mate for the male that had been previously acquired. These are specialized feeders, and it is difficult to provide suitable food, but they are now thriving on the somewhat incongruous diet of bamboo leaves and pablum.

A female bush dog (*Speothos venaticus*) was obtained. This small, reddish, short-legged dog is seldom exhibited in captivity.

A pair of Père David's deer (*Elaphurus davidianus*) were secured from the New York Zoological Society. These are the first of their kind to be exhibited in this Zoo. They are relatively large deer that somewhat resemble the American elk and are of particular interest because they are now extinct in their native haunts in China, but are being raised in captivity from specimens that were transported to England from China many years ago.

A pair of rare and beautifully marked Mearns's quail (*Cyrtonyx montezumae mearnsi*) and five other kinds of quail of the southwestern United States that are being raised in captivity were obtained.

From East Africa the Zoo received two examples of yellow-breasted sunbirds (*Cinnyris venustus*) and four dark malachite sunbirds (*Nectarinia johnstoni*), which are beautiful and rare in collections.

The Zoo was fortunate in obtaining direct from Africa 13 three-horned chameleons (*Chamaeleon jacksoni*) and 3 of a smaller hornless type with a peculiarly marked head casque (*Chamaeleon taitensis*). The three-horned type has a great range of variation in the species, some having three long horns, others only two horns, and some no horns.

Three specimens of the gliding tree snake (*Chrysopelea ornata*) of southern Asia were obtained. These are active rear-fanged tree snakes that are of no particular danger to man. They catch geckos and other lizards and small animal life. They flatten the posterior

portion of their body, jump from an elevated location, and glide downward through the air.

BIRTHS AND HATCHINGS

Conditions under which animals are kept on exhibition are usually not favorable for breeding or raising young. However, occasionally young are born or hatched that are of outstanding interest to the public, and are valuable as additions to the group, or for exchange.

The giraffes (*Giraffa camelopardalis*) produced two young during the year. It would be pleasing to have a considerable herd of giraffes that could be built up from the young that are born here, but accommodations are not adequate for a large group of these animals, and so the young are used in exchanges to obtain other animals that are needed.

The Chinese water deer (*Hydropotes inermis*) produced three young that survived during the year. This rate of increase is rapidly building up an excellent group of these attractive little animals.

During the year the colony of pygmy hippopotamus (*Choeropsis liberiensis*) gave birth to two young. These are valuable animals and the surplus is exchanged for other species, the last one helping to pay for a young rhinoceros.

The little colony of the rather showy slender-tailed cloud rats (*Phloeomys cumingi*) is gradually increasing. This year there were two births of one each. Both young are thriving.

The hybrid Alaska brown bears (*Ursus gyas*) and polar bears (*Thalarctos maritimus*) again produced a litter of three cubs, but unfortunately the young did not live.

The group of African porcupines (*Hystrix galeata*) was augmented by the birth of one more. The care that is given the new-born young is an outstanding demonstration of a group defending its young. The parents and older brothers and sisters keep the young between them almost constantly and maintain an unbroken front of long sharp spines projecting in all directions around the baby.

Barbara, the female hybrid gibbon (*Hylobates agilis* × *H. lar pileatus*) gave birth to a baby that unfortunately lived only about a week.

The pacas (*Cuniculus paca*) produced another young.

The crested screamers (*Chauna torquata*) hatched two eggs. Not only were these two birds very desirable additions to the collection, but the growing young are attractive and arouse much interest.

The colony of black-crowned night herons (*Nycticorax nycticorax hoactli*) continues to thrive as it has for many years, and this year raised 12 young. They are not rarities, but it is interesting to note that they do well in captivity.

The sharp-tailed sand boas (*Eryx thebaicus*), received from Dr. Kuntz, produced five young that are thriving.

One morning a number of baby shovel-nosed skinks (*Scincus officinalis*) were found darting in and out of the sand at the bottom of the cage which housed the collection sent to the Zoo by Dr. Kuntz. Twenty survived.

It was gratifying to find a young White's skink (*Egernia whitii*) in the cage in which a group of Australian skinks had been since November 1951.

During the year several of the reptiles laid eggs. This is always encouraging, and an effort is made to hatch the more promising ones. A few of the eggs, or those that seem sterile, are sent to the National Museum for its collection of preserved specimens. Those reptiles that laid eggs this year were:

Matamata turtle (*Chelys fimbriata*)	20
Small snake-necked turtles (*Hydromedusa tectifera*)	4
American crocodile (*Crocodylus acutus*)	36
Chinese alligator (*Alligator sinensis*)	14
Indian rock python (*Python molurus*)	36
Pilot black snake (*Elaphe obsoleta obsoleta*)	18

Following is a complete list of the births and hatchings:

MAMMALS

Scientific name	*Common name*	*Number*
Ammotragus lervia	Aoudad	5
Bibos gaurus	Gaur	1
Bos taurus	British Park cattle	3
	West Highland cattle	1
Capra hircus	Domestic goat	1
Cebus fatuellus	Weeping capuchin	1
Cercopithecus aethiops sabaeus × *C. a. pygerythrus.*	Green guenon × vervet guenon hybrid.	1
Cervus canadensis	American elk	1
Cervus elaphus	Red deer	2
Cervus nippon	Japanese deer	2
Choeropsis liberiensis	Pygmy hippopotamus	1
Cholocpus didactylus	Two-toed sloth	2
Cuniculus paca	Paca	1
Dama dama	Brown fallow deer	5
	White fallow deer	3
Equus burchellii bohmi	Grant's zebra	1
Erythrocebus patas	Patas monkey	1
Felis leo	Lion	7
Felis pardus	Black leopard	2
Giraffa camelopardalis	Nubian giraffe	2
Hydropotes inermis	Chinese water deer	7
Hylobates agilis × *H. lar pileatus*	Hybrid gibbon (2d generation).	1
Hystrix galeata	African porcupine	2
Lama glama	Llama	1
Leontocebus rosalia	Silky marmoset	1
Macaca mulatta	Rhesus monkey	1
Macaca sylvanus	Barbary ape	1
Myocastor coypus	Coypu	3
Odocoileus virginianus	White-tailed deer	1
Phlocomys cumingi	Slender-tailed cloud rat	3
Taurotragus oryx	Eland	1
Thalarctos maritimus × *Ursus middendorffi*	Hybrid bear (2d generation)	5
Vulpes fulva	Silver fox	2
	Red fox	2

BIRDS

Anas platyrhynchos	Mallard duck	18
Branta canadensis	Canada goose	8
Chauna torquata	Crested screamer	2
Columba livia	Domestic pigeon	1
Gallus gallus	Silky bantam fowl	1
Larus novaehollandiae	Silver gull	6
Nycticorax nycticorax hoactli	Black-crowned night heron	12
Padda oryzivora	Java finch	8
Pavo cristatus	Peafowl	1
Porphyrio poliocephalus	South Pacific swamp hen	3
Streptopelia decaocto	Ring-necked dove	23
Taeniopygia castanotis	Zebra finch	8

REPTILES

Egernia whitii	White's skink	1
Eryx thebaicus	Sharp-tailed sand boa	5
Scincus officinalis	Shovel-nosed skink	23

MAINTENANCE AND IMPROVEMENTS

Maintenance and repair work at the Zoo suffered considerably during the fiscal year 1954 owing mainly to shortage of funds for the hire of personnel. Being forced to absorb salary increases, the Zoo could employ but little temporary labor and also had to leave vacant permanent positions on the maintenance staff.

The routine work of the division of maintenance and construction, which is carried on practically every day of the year, consists of such varied tasks as the removal of stoppages from drains and sewers, repairs of faucets, doors, cages, water lines, steam lines, boilers, refrigeration equipment, buildings, roads, and walks, and innumerable miscellaneous jobs necessary to keep the National Zoological Park in a safe and presentable condition. This year, as in the previous year, because of shortage of manpower due to lack of funds, only the most urgently needed repairs could be undertaken. Consequently maintenance of the grounds, as well as the physical plant, has been at a minimum.

No serious permanent harm has resulted, but it will take some time to catch up on neglected work such as the fight against poison ivy, the trimming or the taking down of old trees, and planting to replace lawns, trees, and shrubs that have deteriorated or become unsuitable for the locations.

The larger jobs done during the year were:

1. The laying of 2,300 linear feet of concrete road shoulders, 2 feet wide and 3 inches thick, to prevent deterioration of the edges of the road.

2. Replacement of badly deteriorated cage fronts in the parrot room with glass fronts.

3. Repair of the lion house roof, which necessitated replacing sheathing and covering with 50 square yards of 240-pound shingles. In

connection with this, 19 metal skylights were reconstructed and set with copper flashings; and 4 new gutters were installed.

4. Installation of 300 linear feet of new paddock fencing with supporting posts in front of the South American camel paddocks, and filling the moat (which had proved unsatisfactory), thereby slightly increasing the size of the paddocks and permitting the animals to come closer to the public.

5. Construction of two concrete shelters in the waterfowl enclosure for the protection of the birds.

6. Installation of automatic heat-regulating devices in the lion house.

7. Adaptation and installation of a small cooling unit in the lower portion of one small cage in the reptile house to provide conditions suitable for the rare New Zealand tuatara, a lizardlike reptile.

8. Slight alteration of a cage in the small-mammal house and installation of an air-conditioned unit for the sea otters.

9. Extension, under contract, of a steam line and wet-return line from the small-mammal house to the bird house, a distance of 1,200 feet. It is believed that this will provide much more reliable heating of the bird house at less cost than was possible with the separate oil-heating plant that was in the bird house. Certainly it eliminates the need for replacement of the boilers and burners in that building.

Along the north side of the road, from the mountain sheep mountain to the South American camel group, a hazardous condition for pedestrians has existed for many years. To view the animals from that side of the road, visitors have had to walk in the street. In December 1953 work was started on filling in the ravine along the road at this point, and by the end of the fiscal year this had progressed far enough to provide pedestrians with plenty of space off the roadway and also parking space for 50 passenger cars. When the fill is completed there will be additional parking space for more cars for a period of a year or two while the fill is settling. Then at least six good-size paddocks can be constructed on it, and sufficient space for a sidewalk and parking for 50 additional cars. Even in its incomplete state this is a great improvement in both attractiveness and utility and is being accomplished without cost to the Government.

Over a period of years there has been a gradual increase in the amount of trimming of trees necessary along the roads, walks, and paths, and in the exhibition area. Because of disease or age, some of the trees are dying and must be cut down. Others must be trimmed to remove dead or broken limbs that might fall and injure people or animals, or damage automobiles or structures.

The job of cleaning up the grounds is a major undertaking. Using all available manpower, it usually takes 5 to 10 days to pick up the trash and restore the Park to a fair degree of presentability after

Easter Sunday and Monday. This work has of necessity been reduced to a minimum, with the result that the Zoo has been criticized by correspondents and the press for the condition of the grounds.

Temporary policemen were employed this year to assist the regular police during days of heaviest attendance or when the force was short-handed. This is a satisfactory arrangement and much more economical than employing additional full-time policemen when the permanent personnel now authorized is adequate for a large proportion of the time.

VISITORS

The estimated number of visitors to the Zoo was 3,616,220, which was 384,770 more than for the year 1953.

Estimated number of visitors for fiscal year 1954

July (1953)	422,000	February	184,700
August	561,500	March	260,600
September	296,000	April	440,770
October	310,000	May	402,800
November	191,200	June	409,500
December	58,150		
January (1954)	79,000	Total	3,616,220

Groups came to the Zoo from schools in Cuba, Mexico, and 30 States, some as far away as Maine, Florida, Mississippi, California, and Wisconsin.

Number of groups from schools

Locality	Number of groups	Number in groups	Locality	Number of groups	Number in groups
Alabama	23	996	Mississippi	6	238
California	1	72	New Hampshire	2	87
Connecticut	7	431	New Jersey	10	808
Cuba	1	70	New York	106	6,959
Delaware	10	478	North Carolina	212	8,036
District of Columbia	80	4,614	Ohio	46	1,836
Florida	7	922	Oklahoma	1	38
Georgia	50	2,998	Pennsylvania	152	8,427
Illinois	4	342	Rhode Island	1	33
Indiana	2	63	South Carolina	48	2,123
Iowa	1	16	Tennessee	45	1,871
Kentucky	5	176	Vermont	1	40
Maine	5	194	Virginia	468	24,739
Maryland	530	33,162	West Virginia	32	2,971
Massachusetts	12	528	Wisconsin	1	83
Mexico	2	51			
Michigan	9	333	Total	1,884	103,926
Minnesota	4	191			

About 2 p. m. each day the cars then parked in the Zoo are counted and listed according to the State, Territory, or country from which they came. This is, of course, not a census of the cars coming to the Zoo, but is valuable in showing the percentage of attendance, by States, of people in private automobiles. Many District of Columbia,

Maryland, and Virginia cars come to the Zoo to bring guests from other States. The tabulation for the fiscal year 1954 is as follows:

	Percent		Percent
Maryland	26.3	New Jersey	1.6
District of Columbia	23.4	Ohio	1.5
Virginia	23.0	West Virginia	1.3
Pennsylvania	4.6	Massachusetts	1.2
New York	2.6	Florida	1.0
North Carolina	1.9	Illinois	.7

The cars that made up the remaining 10.9 percent came from every one of the remaining States, as well as from Alaska, Austria, British Columbia, Canada, Canal Zone, Cuba, Germany, Hawaii, Honduras, Liberia, Mexico, Nova Scotia, Puerto Rico, South America, and the West Indies.

On the days of even small attendance there are cars parked in the Zoo from at least 15 States, Territories, the District, and foreign countries. On average days there are cars from about 22 States, Territories, the District, and foreign countries; and during the periods of greatest attendance the cars represent not less than 34 different States, Territories, and countries.

COOPERATION

At all times special efforts are made to maintain friendly contacts with other Government and State agencies, private concerns and individuals, and scientific workers for mutual assistance. As a result the Zoo receives much help and advice and many valuable specimens, and in turn the Zoo furnishes information and, whenever possible, specimens it does not need.

Dr. Willard H. Eyestone, veterinary pathologist of the National Cancer Institute, Bethesda, Md., continued making autopsies on animals that have died in the Zoo, in order to obtain information regarding cancer and other diseases affecting human beings.

Special acknowledgment is due to the United States Despatch Agent in New York City, Howard Fyfe, an officer of the State Department, who has frequently been called upon to clear shipments of animals coming from abroad. This he has done, often at great personal inconvenience, and the animals have been forwarded to Washington without the loss of a single specimen.

As in previous years the Zoo received gifts of various kinds of food that could not be sold for human consumption but was suitable for animals. Some of this material was turned over to the Zoo at the suggestion of the United States Food and Drug Administration and the District of Columbia food inspectors. This helps considerably to hold purchases to a minimum. Through the office of United States Marshal W. Bruce Matthews, food that had been condemned by the

courts was sent to the Zoo for the animals. This consisted of 60 cartons of large prunes and 237 bags of green split peas.

From the District of Columbia Health Department 70 crates of ear corn were received. Other contributions were:

600 pounds of candy from the Harris Candy & Specialty Co.
28 cartons of grape-nuts flakes from the Mazo-Lerch Co.
26 cartons of Italian tunafish from Chicken-of-the-Sea, Inc.
100 pounds of sunflower seed from General Services Administration.

The National Institutes of Health, the Navy Medical Center, the Army Medical Center, Animal Farm Unit, Camp Detrick, and the Nutritional Laboratory of the Department of Agriculture gave the Zoo mice, rats, guinea pigs, rabbits, and other animals no longer suitable for their purposes.

The Poultry Division of the Department of Agriculture gave a considerable number of day-old chicks that were hatched in connection with certain of their experiments.

The practice has been continued of picking up from grocery stores in the vicinity of the Zoo quantities of discarded green material such as beet tops, celery stalks, and the outer leaves of cabbage, cauliflower, and lettuce, and some fruit. This provides an abundance of greens for the animals and helps reduce purchase of such foods.

In a few instances such materials as rice, flour, and beans, unacceptable for human use, have been purchased at low prices from General Services Administration or commercial firms.

ROCK CREEK–POTOMAC PARKWAY

The proposed northward extension of the Rock Creek–Potomac Parkway through the Zoo on the east side of the creek by a bridge near the location of the lower ford, a tunnel through the hill on which the office is located, and the construction of the roadway northward from the tunnel between the creek and Adams Mill Road will bring about a serious condition for the Zoo. The following changes will be necessary before the highway project can be begun: (1) A fence must be constructed on the west side of the creek to connect the southern boundary with the northern boundary, so that the Zoo can at all times be properly enclosed. (2) Parking spaces must be developed on Zoo ground to make up as far as is possible for the loss of parking spaces on the east side of the creek that now accommodate 55 buses and 230 cars. (3) New paddocks must be constructed to replace those that will be eliminated by the construction of the new parking lot. (4) An office building for the administration of the Zoo should be constructed on the Zoo's grounds at a convenient location. (5) The coal bunker for the central heating plant must be enlarged.

NEEDS OF THE ZOO

Replacement of antiquated structures that have long since ceased to be suitable for the purposes for which they are used is still the principal need of the Zoo. Urgently required are:

A building to house antelopes and other medium-sized hoofed animals that require a heated building.

A new administration building to replace the 149-year-old historic landmark that is still in use as an office building but that is neither suitably located nor well adapted for the purpose.

A fireproof service building for receiving shipments of animals, quarantining them, and caring for those in ill health or those that cannot be placed on exhibition.

A new ventilating system for the bird house.

Lesser items of equipment that are needed are a vacuum pump for more efficient and economical operation of the heating system in the reptile house; a band saw to replace one that is more than 40 years old; and an air compressor for general use about the Park.

The enclosures and pools for beavers, otters, seals, and nutrias, in the ravine, need to be reconstructed. Owing to lack of funds for upkeep, and consequent deterioration, this area has become unsightly and inadequate for the proper care and exhibition of these animals.

In addition to new buildings, new paddocks are needed. Over the years, space for the exhibition of such animals as deer, sheep, goats, and other hoofed animals has been curtailed so that the collection no longer contains the proper assortment of these attractive and valuable animals. This has been brought about by the natural deterioration of materials, making some of the paddocks no longer usable; elimination of some paddocks for the construction of buildings on the sites; and abandonment of some paddocks that were in undesirable locations. Further abandonment of some paddocks is imminent to make way for parking space for cars and buses to offset losses in such space that will occur if the Rock Creek–Potomac Parkway is extended through the Zoo property on the east side of the creek. Construction of ten new paddocks and rehabilitation of six old ones are urgently needed.

Provision of new parking space necessitates grading and surfacing about 14,000 square yards of land in several different locations.

The establishment of parking space near the mechanical shops will make unavailable an area that has been used for the storage of a reserve pile of coal. As this location has never been an entirely satisfactory one, it would be highly desirable at this time to build an addition to the regular coal bunker to increase the capacity and eliminate the need for maintaining a separate reserve pile.

The steadily increasing popularity of the Zoo, as a source of both entertainment and education, has developed such a volume of requests

for information that there is now need for an additional scientist to share the load of answering queries and to assist in other administrative work so that the Director and Assistant Director can devote more time to general supervision of the Zoo.

One additional general mechanic is needed to assist the maintenance personnel in what has hitherto been a losing race in trying to keep pace with natural deterioration in the structures. The newest of the exhibition buildings are 17 years old, the reptile house is 23 years old, and the bird house is 26 years old. The minimum of maintenance has fully occupied the mechanical force, mainly on the larger structures, so that there has been almost no opportunity to take care of the lesser structures such as paddocks and outside cages, with the result that an increasing number of these are unusable.

Two additional permanent laborers are needed for proper maintenance, removal of dead or fallen tree limbs and other safety hazards, and repair of walks, guard rails, and other structures, for the protection of the public.

To comply with the requirements of keeping property and inventory records, in accordance with the program laid down by the General Services Administration, by authority of Federal Property and Administrative Services Act of 1949 (Public Law 152, 81st Congress, approved June 30, 1949), General Regulation 100 of the General Accounting Office, and Budget-Treasury Regulation No. 1, there is need for three additional clerks.

ANIMALS IN THE COLLECTION ON JUNE 30, 1954

MAMMALS

MONOTREMATA

Scientific name	*Common name*	*Number*
Tachyglossidae:		
Tachyglossus aculeatus	Echidna, or spiny anteater	2

MARSUPIALIA

Didelphiidae:		
Caluromys philander	Woolly opossum	2
Didelphis marsupialis virginiana	Opossum	2
Marmosa mitis	Mouse opossum	3
Phalangeridae:		
Petaurus norfolcensis	Australian "flying" phalanger	5
Trichosurus vulpecula	Australian long-eared opossum	2
Phascolomidae:		
Lasiorhinus latifrons	Hairy-nosed wombat	3
Vombatus hirsutus	Mainland wombat	1
Macropodidae:		
Dendrolagus inustus	New Guinea tree kangaroo	1
Macropus giganteus	Great gray kangaroo	4
	Albino great gray kangaroo	1
Macropus rufus	Great red kangaroo	1
Wallabia agilis	Agile wallaby	2

INSECTIVORA

Soricidae:		
Blarina brevicauda	Greater short-tailed shrew	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

MAMMALS—Continued

PRIMATES

Scientific name	*Common name*	*Number*
Tupaiidae:		
Tupaia montana baluensis	Kinabalu tree shrew	3
Lemuridae:		
Lemur macaco	Acoumba lemur	2
Lemur mongoz	Mongoose lemur	1
Lorisidae:		
Nycticebus coucang	Slow loris	4
Cebidae:		
Aotus trivirgatus	Douroucouli, or night monkey	2
Ateles geoffroyi vellerosus	Spider monkey	5
Cebus albifrons	Pale capuchin	8
Cebus capucinus	White-throated capuchin	2
Cebus fatuellus	Weeping capuchin	1
Lagothrix lagotricha	Woolly monkey	3
Saimiri sciureus	Squirrel monkey	7
Callithricidae:		
Leontocebus rosalia	Silky or lion-headed marmoset	4
Cercopithecidae:		
Allenopithecus nigroviridis	Allen's monkey	1
Cercocebus albigena	Gray-cheeked mangabey	2
Cercocebus aterrimus	Black-crested mangabey	4
Cercocebus aterrimus opdenboschii	Opdenbosch's black-crested mangabey.	3
Cercocebus chrysogaster	Golden-bellied mangabey	1
Cercocebus fuliginosus	Sooty mangabey	4
Cercocebus galeritus agilis	Agile mangabey	2
Cercocebus torquatus	Red-crowned mangabey	2
Cercopithecus aethiops pygerythrus	Vervet guenon	2
Cercopithecus aethiops sabaeus	Green guenon	10
Cercopithecus aethiops sabaeus × *C. a. pygerythrus*	Hybrid, green guenon × vervet guenon.	3
Cercopithecus cephus	Mustached guenon	2
Cercopithecus diana	Diana monkey	2
Cercopithecus diana roloway	Roloway monkey	1
Cercopithecus neglectus	De Brazza's guenon	2
Cercopithecus nictitans erythrogaster	Red-bellied guenon	1
Cercopithecus nictitans petaurista	Lesser white-nosed guenon	2
Cercopithecus preussi	Preussi's guenon	1
Colobus polykomos	White-tailed colobus	1
Comopithecus hamadryas	Hamadryas baboon	2
Erythrocebus patas	Patas monkey	2
Macaca irus	Crab-eating macaque	1
Macaca irus mordax	Javan macaque	3
Macaca lasiotis	Chinese macaque	1
Macaca maurus	Moor macaque	1
Macaca mulatta	Rhesus monkey	14
Macaca nemestrina	Pig-tailed monkey	1
Macaca philippinensis	Philippine macaque	7
Macaca sinica	Toque, or bonnet monkey	1
Macaca speciosa	Red-faced macaque	1
Macaca sylvanus	Barbary ape	7
Mandrillus sphinx	Mandrill	2
Papio comatus	Chacma baboon	2
Papio cynocephalus	Golden baboon	3
Presbytis phayrei	Phayre's langur	1
Pongidae:		
Hylobates agilis × *H. lar pileatus*	Hybrid gibbon	1
Hylobates hoolock	Hoolock gibbon	1
Hylobates lar	White-handed gibbon	1
Hylobates moloch	Wau-wau gibbon	1
Hylobates sp. (young)	Blond gibbons	4
Pan troglodytes	Chimpanzee	4
Pongo pygmaeus abelii	Orangutan	2

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

MAMMALS—Continued

EDENTATA

Scientific name	*Common name*	*Number*
Myrmecophagidae:		
Myrmecophaga tridactyla	Giant anteater	1
Bradypodidae:		
Choloepus didactylus	Two-toed sloth	7
Dasypodidae:		
Chaetophractus villosus	Hairy armadillo	2

LAGOMORPHA

Leporidae:		
Oryctolagus cuniculus	Domestic rabbit	26
Sylvilagus palustris	Swamp rabbit	1

RODENTIA

Sciuridae:		
Callosciurus caniceps	Southern Asiatic squirrel	1
Callosciurus erythraeus	Southern Asiatic squirrel	4
Callosciurus nigrovittatus	Southern Asiatic squirrel	1
Callosciurus sp	Southern Asiatic squirrel	1
Callospermophilus lateralis	Albino golden-mantled ground squirrel.	1
Callospermophilus lateralis chrysodeirus.	Golden-mantled ground squirrel	1
Citellus tridecemlineatus	Thirteen-lined ground squirrel	1
Cynomys ludovicianus	Plains prairie dog	10
Eutamias quadrivittatus	Western chipmunk	1
Marmota monax	Woodchuck, or ground hog	10
Menetes berdmorei	Berdmore's squirrel	4
Ratufa indica	Giant Indian squirrel	1
Sciurus carolinensis	Gray squirrel	4
Sciurus niger niger	Fox squirrel	1
Tamias striatus	Eastern chipmunk	1
Tamiasciurus hudsonicus	Red squirrel	2
Cricetidae:		
Mesocricetus auratus	Golden hamster	10
Neotoma lepida	Pack rat	1
Neotoma magister	Allegheny wood rat	2
Oryzomys palustris	Rice rat	4
Peromyscus maniculatus	White-footed mouse	3
Muridae:		
Acomys cahirinus	Egyptian spiny mouse	6
Bandicota bengalensis	Lesser bandicoot rat	3
Cricetomys gambianus	Giant pouched rat	4
Mus musculus	White and other domestic mice	10
Phloeomys cumingi	Slender-tailed cloud rat	7
Pitymys pinetorum	Pine mouse	2
Rattus bowersi	Bower's tree rat	1
Rattus rajah	Rajah spiny rat	2
Rattus infraluteus	Kinabalu giant rat	3
Rattus rattus thai	Thailand rat	6
Rattus sabanus	Large Malayan tree rat	6
Rattus whiteheadi	Whitehead's rat	3
Hystricidae:		
Acanthion brachyurum	Malayan porcupine	2
Hystrix galeata	African porcupine	5
Trichys lipura	Bornean porcupine	3
Caviidae:		
Cavia porcellus	Guinea pig	15
Dasyproctidae:		
Cuniculus paca	Paca	6
Dasyprocta punctata	Speckled agouti	2
Dasyprocta sp	Agouti	7

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

MAMMALS—Continued

RODENTIA—continued

Scientific name	*Common name*	*Number*
Chinchillidae:		
Chinchilla chinchilla	Chinchilla	1
Lagidium viscaccia	Peruvian viscacha	1
Capromyidae:		
Myocastor coypus	Coypu	3
Bathyergidae:		
Cryptomys lugardi	Mole rat	2

CARNIVORA

Canidae:		
Canis antarcticus	Dingo	1
Canis latrans	Coyote	1
Canis niger rufus	Texas red wolf	1
Fennecus zerda	Fennec fox	2
Nyctereutes procyonoides	Raccoon-dog	6
Otocyon megalotis	Big-eared fox	4
Speothos venaticus	Bush dog	2
Urocyon cinereoargenteus	Gray fox	14
Vulpes fulva	Red fox	12
	Silver fox	4
Ursidae:		
Euarctos americanus	Black bear	2
Helarctos malayanus	Malayan sun bear	3
Selenarctos thibetanus	Himalayan bear	2
Selenarctos thibetanus japonicus	Japanese bear	1
Selenarctos thibetanus ussuricus	Korean bear	2
Thalarctos maritimus	Polar bear	1
Thalarctos maritimus × *Ursus middendorffi*	Hybrid bear	4
	Hybrid bear, second generation	1
Tremarctos ornatus	Spectacled bear	1
Ursus arctos	European brown bear	1
Ursus arctos occidentalis	Syrian brown bear	2
Ursus gyas	Alaskan Peninsula bear	2
Ursus horribilis	Grizzly bear	2
Ursus middendorffi	Kodiak bear	1
Ursus sitkensis	Sitka brown bear	3
Ursus sp	Alaska brown bear	1
Procyonidae:		
Ailurus fulgens	Lesser panda	2
Bassariscus astutus	Ringtail, or cacomistle	2
Nasua narica	Coatimundi	2
Nasua nasua	Red coatimundi	1
Potos flavus	Kinkajou	3
Potos sp	Dwarf kinkajou	2
Procyon lotor	Raccoon	15
	Black raccoon	4
	Albino raccoon	1
Mustelidae:		
Lutra canadensis vaga	Florida otter	1
Meles meles leptorynchus	Chinese badger	1
Mephitis mephitis nigra	Skunk	14
Mustela eversmanni	Ferret	1
	Albino ferret	2
Mustela frenata noveboracensis	Weasel	2
Spilogale phenax	California spotted skunk	1
Taxidea taxus	American badger	2
Tayra barbara	Tayra	2

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

MAMMALS—Continued

CARNIVORA—continued

Scientific name	*Common name*	*Number*
Viverridae:		
Arctogalidia trivirgata stigmatica	Small-toothed civet	1
Atilax paludinosus	African water mongoose	2
Civettictis civetta	African civet	1
Crossarchus obscurus	Kusimanse	1
Genetta tigrina	Genet	3
Ichneumia albicaudatus	White-tailed mongoose	1
Paguma larvata taivana	Formosan masked civet	1
Paradoxurus hermaphroditus	Palm civet	1
Viverra tangalunga	Ground civet	1
Hyaenidae:		
Crocuta crocuta germinans	East African spotted hyena	2
Felidae:		
Acinonyx jubata	Cheeta	2
Felis chaus	Jungle cat	3
Felis concolor	Puma	3
Felis concolor × *F. c. patagonica*	Hybrid, North American puma × South American puma.	5
Felis leo	Lion	6
Felis onca	Jaguar	3
Felis pajeros	Pampas cat	1
Felis pardalis	Ocelot	1
Felis pardus	African leopard	4
	Black leopard	4
Felis tigris	Bengal tiger	3
Felis tigris sumatrae	Sumatran tiger	1
Felis wiedi	Margay cat	1
Lynx rufus	Bobcat	2

PINNIPEDIA

Otariidae:		
Zalophus californianus	California sea-lion	3

TUBULIDENTATA

Orycteropodidae:		
Orycteropus afer	Aardvark, or ant bear	1

PROBOSCIDEA

Elephantidae:		
Elephas maximus	Asiatic elephant	3

HYRACOIDEA

Procavidae:		
Procavia capensis	Cape hyrax	1

PERISSODACTYLA

Equidae:		
Equus burchellii antiquorum	Chapman's zebra	1
Equus burchellii bohmi	Grant's zebra	5
Equus caballus	Horse	1
Equus grevyi	Grevy's zebra	4
Equus kiang	Asiatic wild ass, or kiang	1
Equus onager	Onager	1
Equus przewalskii	Mongolian wild horse	2
Tapiridae:		
Tapirus terrestris	Brazilian tapir	1
Rhinocerotidae:		
Diceros bicornis	African rhinoceros	2
Rhinoceros unicornis	Great Indian one-horned rhinoceros.	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

MAMMALS—Continued

ARTIODACTYLA

Scientific name	*Common name*	*Number*
Suidae:		
Sus scrofa	European wild boar	1
Tayassuidae:		
Tayassu tajacu	Collared peccary	1
Hippopotamidae:		
Choeropsis liberiensis	Pygmy hippopotamus	8
Hippopotamus amphibius	Hippopotamus	2
Camelidae:		
Camelus bactrianus	Bactrian camel	2
Camelus dromedarius	Single-humped camel	2
Lama glama	Llama	8
Lama glama guanicoe	Guanaco	4
Lama pacos	Alpaca	4
Vicugna vicugna	Vicuña	1
Cervidae:		
Cervus canadensis	American elk	6
Cervus elaphus	Red deer	4
Cervus nippon	Japanese deer	7
Cervus nippon manchuricus	Dybowsky's deer	2
Dama dama	Fallow deer	21
	White fallow deer	15
Elaphurus davidianus	Père David's deer	2
Hydropotes inermis	Chinese water deer	10
Mazama sartorii	Mazama	1
Odocoileus virginianus	White-tailed deer	7
Odocoileus virginianus costaricensis	Central American white-tailed deer.	3
Giraffidae:		
Giraffa camelopardalis	Nubian giraffe	6
Giraffa reticulata	Reticulated giraffe	1
Antilocapridae:		
Antilocapra americana	Pronghorn antelope	1
Bovidae:		
Ammotragus lervia	Aoudad	19
Anoa depressicornis	Anoa	2
Bibos gaurus	Gaur	5
Bison bison	American bison	8
Bos indicus	Zebu	2
Bos taurus	West Highland or Kyloe cattle	4
	British Park cattle	10
Bubalus bubalis	Water buffalo	2
Capra aegagrus cretensis	Agrimi goat	1
Capra hircus	Domestic goat	8
Cephalophus maxwellii	Maxwell's duiker	1
Cephalophus nigrifrons	Black-fronted duiker	2
Hemitragus jemlahicus	Tahr	1
Ovis musimon	Mouflon	1
Poephagus grunniens	Yak	5
Pseudois nayaur	Bharal or blue sheep	1
Syncerus caffer	African buffalo	3
Taurotragus oryx	Eland	4

BIRDS

SPHENISCIFORMES

Spheniscidae:		
Spheniscus demersus	Jackass penguin	2
Spheniscus humboldti	Humboldt's penguin	4

STRUTHIONIFORMES

Struthionidae:		
Struthio camelus	Ostrich	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

RHEIFORMES

Scientific name	*Common name*	*Number*
Rheidae:		
Rhea americana	Common rhea	2

CASUARIFORMES

Casuariidae:		
Casuarius unappendiculatus occipitalis.	Island cassowary	1
Casuarius unappendiculatus unappendiculatus.	One-wattled cassowary	1
Dromiceiidae:		
Dromiceius novaehollandiae	Common emu	4

TINAMIFORMES

Tinamidae:		
Crypturellus cinnamomeus	Sallé's tinamou	2
Crypturellus soui	Little tinamou	1

PELECANIFORMES

Pelecanidae:		
Pelecanus erythrorhynchus	White pelican	8
Pelecanus occidentalis occidentalis	Brown pelican	2
Pelecanus onocrotalus	Old World white pelican	2
Phalacrocoracidae:		
Phalacrocorax auritus albociliatus	Farallon cormorant	1

CICONIFORMES

Ardeidae:		
Ardea herodias	Great blue heron	2
Leucophoyx thula	Snowy egret	3
Notophoyx novaehollandiae	White-faced heron	1
Nyctanassa violacea	Yellow-crowned night heron	1
Nycticorax nycticorax hoactli	Black-crowned night heron	44
Tigrisoma lineatum	Tiger bittern	3
Balaenicipitidae:		
Balaeniceps rex	Shoebill	1
Cochleariidae:		
Cochlearius cochlearius	Boat-billed heron	1
Ciconiidae:		
Ciconia alba	White stork	1
Dissoura episcopus	Woolly-necked stork	1
Ibis cinereus	Malayan painted stork	1
Jabiru mycteria	Jabiru	1
Leptoptilus crumeniferus	Marabou	1
Leptoptilus javanicus	Lesser adjutant	2
Mycteria americana	Wood ibis	1
Threskiornithidae:		
Ajaia ajaja	Roseate spoonbill	3
Eudocimus albus	White ibis	3
Eudocimus ruber	Scarlet ibis	3
Threskiornis melanocephala	Black-headed ibis	1
Phoenicopteridae:		
Phoenicopterus antiquorum	Old World flamingo	2
Phoenicopterus chilensis	Chilean flamingo	6
Phoenicopterus ruber	Cuban flamingo	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

ANSERIFORMES

Scientific name	*Common name*	*Number*
Anhimidae:		
Chauna torquata	Crested screamer	6
Anatidae:		
Aix sponsa	Wood duck	6
Anas acuta	Pintail	4
Anas discors	Blue-winged teal	2
Anas platyrhynchos	Mallard duck	22
	White mallard duck	6
Anas platyrhynchos × *A. acuta*	Hybrid, mallard duck × pintail duck.	1
Anas platyrhynchos domestica	Peking duck	80
Anas poecilorhyncha	Indian spotted-bill duck	1
Anas rubripes	Black duck	3
Anas spinicauda	Chilean pintail	1
Anser albifrons	White-fronted goose	3
Anser albifrons subsp	Greenland white-fronted goose	1
Anser anser domesticus	Toulouse goose	4
Anseranas semipalmata	Australian pied goose	1
Aythya affinis	Lesser scaup	2
Aythya americana	Red-headed duck	2
Aythya collaris	Ring-necked duck	1
Aythya valisineria	Canvasback duck	2
Branta canadensis	Canada goose	10
Branta canadensis occidentalis	White-cheeked goose	27
Branta canadensis × *Chen caerulescens.*	Hybrid, Canada goose × blue goose.	1
Branta hutchinsii	Hutchins's goose	11
Branta hutchinsii minima	Cackling goose	8
Cairina moschata	Moscovy duck	3
Cereopsis novaehollandiae	Cape Barren goose	2
Chen atlantica	Snow goose	12
Chen caerulescens	Blue goose	2
Chen hyperborea	Lesser snow goose	2
Chen rossii	Ross's snow goose	4
Chenopis atrata	Black swan	3
Chloephaga leucoptera	Upland goose	2
Coscoroba coscoroba	Coscoroba	1
Cygnopsis cygnoides	Domestic swan-goose	1
Cygnus columbianus	Whistling swan	6
Dendrocygna autumnalis	Black-bellied tree duck	46
Eulabeia indica	Bar-headed goose	6
Mareca americana	Baldpate	2
Netta rufina	Red-crested pochard	1
Nettion carolinense	Green-winged teal	2
Plectropterus gambensis	Spur-winged goose	1
Tadorna tadorna	Shelldrake	2

FALCONIFORMES

Cathartidae:		
Cathartes aura	Turkey vulture	4
Coragyps atratus	Black vulture	2
Gyps rueppellii	Ruppell's vulture	2
Sarcoramphus papa	King vulture	2
Vultur gryphus	Andean condor	2
Sagittariidae:		
Sagittarius serpentarius	Secretarybird	2
Accipitridae:		
Aquila chrysaetos canadensis	Golden eagle	1
Buteo fuscescens	Red-backed buzzard	1
Buteo jamaicensis	Red-tailed hawk	6
Buteo lineatus lineatus	Red-shouldered hawk	2

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

FALCONIFORMES—continued

Scientific name	*Common name*	*Number*
Accipitridae—Continued		
Buteo platypterus	Broad-winged hawk	1
Butco poecilochrous	Buzzard eagle	1
Buteo swainsoni	Swainson's hawk	2
Haliaeetus leucocephalus	Bald eagle	8
Haliaeetus leucogaster	White-breasted sea eagle	1
Haliastur indus	Brahminy kite	3
Harpia harpyja	Harpy eagle	1
Milvago chimango	Chimango	3
Milvus migrans parasitus	African yellow-billed kite	2
Pandion haliaetus carolinensis	Osprey	3
Spizaetus ornatus	Ornate hawk eagle	1
Falconidae:		
Falco mexicanus	Prairie falcon	1
Falco rusticolus obsoletus	Gyrfalcon	1
Falco sparverius	Sparrow hawk	4
Polyborus plancus	South American caracara	3

GALLIFORMES

Megapodiidae:		
Alectura lathami	Brush turkey	2
Cracidae:		
Crax alberti	Blue-cered curassow	4
Crax rubra	Yellow-cered curassow	3
Ortalis motmot	Chachalaca	1
Penelope boliviana	Crested guan	2
Phasianidae:		
Argusianus argus	Argus pheasant	1
Chrysolophus pictus	Golden pheasant	1
Colinus virginianus	Bobwhite	1
	Red bobwhite	1
Colinus virginianus ridgwayi	Masked bobwhite	2
Crossoptilon auritum	Blue-cered pheasant	1
Cyrtonyx montezumae mearnsi	Mearns's quail	1
Gallus gallus	Bantam fowl	26
	Fighting fowl	7
	Red jungle fowl	1
Gennaeus leucomelanus	Nepal kaleege	2
Hierophasis swinhoii	Swinhoe's pheasant	1
Lophortyx californica	California quail	2
Lophortyx gambeli	Gambel's quail	2
Odontophorus gujanensis marmoratus	Marbled Guiana quail	1
Pavo cristatus	Peafowl	13
Phasianus torquatus	Ring-necked pheasant	2
	White ring-necked pheasant	1
Numididae:		
Guttera plumifera schubotzi	Uele crested guinea fowl	2
Numida meleagris	White guinea fowl	5

GRUIFORMES

Gruidae:		
Anthropoides virgo	Demoiselle crane	1
Balearica pavonina	West African crowned crane	1
Balearica regulorum gibbericeps	East African crowned crane	1
Grus canadensis	Sandhill crane	1
Grus leucogeranus	Siberian crane	1
Psophiidae:		
Psophia crepitans	Gray-backed trumpeter	1
Psophia leucoptera	White-backed trumpeter	2
Psophia viridis	Green-backed trumpeter	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

GRUIFORMES—continued

Scientific name	*Common name*	*Number*
Rallidae:		
Aramides cajanea	Wood rail	3
Fulica americana	American coot	3
Gallinula chloropus cachinnans	Florida gallinule	4
Laterallus leucopyrrhus	Black-and-white crake	1
Porphyrio poliocephalus	South Pacific swamp hen	2
Cariamidae:		
Cariama cristata	Cariama or seriama	2
Otidae:		
Chlamydotis undulata macqueenii	MacQueen's bustard	2

CHARADRIIFORMES

Recurvirostridae:		
Himantopus mexicanus	Black-necked stilt	1
Burhinidae:		
Burhinus bistriatus	South American thick-knee	1
Haematopodidae:		
Haematopus ostralegus	European oystercatcher	2
Charadriidae:		
Charadrius vociferus	Killdeer	1
Laridae:		
Larus argentatus	Herring gull	1
Larus delawarensis	Ring-billed gull	2
Larus dominicanus	Kelp gull	2
Larus novaehollandiae	Silver gull	8

COLUMBIFORMES

Columbidae:		
Chaemepelia minuta	Plain-breasted ground dove	1
Columba livia	Domestic pigeon	15
Columba nigrirostris	Short-billed pigeon	1
Gallicolumba luzonica	Bleeding-heart dove	1
Goura victoria	Victoria crowned pigeon	2
Streptopelia decaocto	Ring-necked dove	30
Streptopelia tranquebarica	Blue-headed ring dove	10
Zenaida asiatica	White-winged dove	3
Zenaidura macroura	Mourning dove	8

PSITTACIFORMES

Psittacidae:		
Amazona aestiva	Blue-fronted parrot	1
Amazona auropalliata	Yellow-naped parrot	5
Amazona ochrocephala	Yellow-headed parrot	3
Amazona oratrix	Double yellow-headed parrot	5
Anodorhynchus hyacinthinus	Hyacinthine macaw	1
Ara ararauna	Yellow-and-blue macaw	5
Ara chloroptera	Red-and-blue macaw	2
Ara macao	Red, blue, and yellow macaw	3
Aratinga pertinax	Rusty-cheeked parrot	2
Callocephalon fimbriatum	Gang-gang cockatoo	7
Calyptorhynchus magnificus	Banksian cockatoo	1
Domicella garrula	Red lory	1
Eclectus pectoralis	Red-sided eclectus	1
Forpus cyanopygius	Little green parakeet	1
Kakatoe alba	White cockatoo	1
Kakatoe ducrops	Solomon Islands cockatoo	2
Kakatoe galerita	Large sulphur-crested cockatoo	11
Kakatoe leadbeateri	Leadbeater's cockatoo	13
Kakatoe moluccensis	Great red-crested cockatoo	1
Kakatoe sanguineus	Bare-eyed cockatoo	7
Melopsittacus undulatus	Grass parakeet	12

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

PSITTACIFORMES—continued

Scientific name	*Common name*	*Number*
Psittacidae—Continued		
Nestor notabilis	Kea	1
Nymphicus hollandicus	Cockatiel	1
Pionus menstruus	Blue-headed conure	1
Polytelis swainsoni	Barraband's parakeet	6
Psittacula eupatria	Red-shouldered parakeet	1
Psittacula krameri	Kramer's parakeet	1

CUCULIFORMES

Cuculidae:		
Eudynamys scolopacea	Koel	1
Musophagidae:		
Tauraco corythaix	South African turaco	1
Tauraco donaldsoni	Donaldson's turaco	1
Tauraco persa	Purple turaco	3

STRIGIFORMES

Tytonidae:		
Tyto alba pratincola	Barn owl	5
Strigidae		
Bubo virginianus	Great horned owl	8
Bubo virginianus elutus	Colombian great horned owl	1
Ketupa ketupu	Malay fishing owl	1
Otus asio	Screech owl	1
Strix varia varia	Barred owl	17

TROGONIFORMES

Trogonidae:		
Prionotelus temnurus	Cuban trogon	7

CORACIIFORMES

Alcedinidae:		
Dacelo gigas	Kookaburra	1
Bucerotidae:		
Anthracoceros coronatus	Pied hornbill	2
Bucorvus abyssinicus	Abyssinian ground hornbill	1
Momotidae:		
Baryphthengus martii	Great rufous motmot	1
Momotus lessoni	Lesson's motmot	2

PICIFORMES

Capitonidae:		
Megalaima asiatica	Blue-throated barbet	1
Ramphastidae:		
Pteroglossus torquatus	Ringed toucanet	8
Ramphastos ariel	Ariel toucan	1
Ramphastos bicolor	Southern red-breasted toucan	1
Ramphastos carinatus	Sulphur-breasted toucan	1
Ramphastos culminatus	White-breasted toucan	1
Ramphastos innominatus	Todd's toucan	1
Ramphastos toco	Toco toucan	2
Ramphastos vitellinus	Northern red-breasted toucan	1

PASSERIFORMES

Cotingidae:		
Chasmorhynchus nudicollis	Bellbird	1
Rupicola rupicola	Orange cock-of-the-rock	3
Rupicola sanguinolenta	Scarlet cock-of-the-rock	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

PASSERIFORMES—continued

Scientific name	*Common name*	*Number*
Corvidae:		
Corvus brachyrhynchos	American crow	4
Corvus corax principalis	Northern raven	2
Corvus insolens	Indian crow	2
Cyanocitta cristata	Blue jay	3
Cyanocorax chrysops	Urraca jay	3
Pica nuttalli	Yellow-billed magpie	1
Pica pica hudsonica	American magpie	2
Urocissa caerulea	Formosan red-billed pie	2
Ptilorhynchidae:		
Ptilonorhynchus violaceus	Bowerbird	6
Paradiseidae:		
Diphylloides magnificus	Magnificent bird-of-paradise	1
Paradisea rubra	Red bird-of-paradise	1
Paradisornis rudophi	Prince Rudolph's bird-of-paradise	1
Schlegelia wilsoni	Wilson's bird-of-paradise	1
Timaliidae:		
Garrulax bicolor	White-headed laughing thrush	2
Pycnonotidae:		
Hcterophasia capistratra	Black-headed sibia	1
Pycnonotus leucogenys	White-cheeked bulbul	1
Mimidae:		
Mimus polyglottos leucopterus	Western mockingbird	1
Mimus polyglottos polyglottos	Eastern mockingbird	1
Turdidae:		
Geokichla citrina	Orange-headed ground thrush	1
Hylocichla mustclina	Wood thrush	1
Platycichla flavipes	Yellow-footed thrush	1
Turdus migratorius	Eastern robin	7
Nectariniidae:		
Cinnyris venustus	Yellow-breasted sunbird	2
Nectarinia johnstoni	Dark malachite sunbird	4
Sturnidae:		
Acridotheres tristis	Common mynah	1
Gracula religiosa	Wattled mynah	3
Gracula religiosa robusta	Nias wattled mynah	2
Lamprocolius purpureus	Glossy starling	3
Spreo superbus	Superb starling	1
Sturnia malabarica	Gray-headed mynah	1
Coerebidae:		
Cyanerpes cyaneus	Purple honeycreeper	6
Dacnis cayana ultramarina	Ultramarine dacnis	4
Parulidae:		
Icteria virens	Yellow-breasted chat	1
Ploceidae:		
Aegintha temporalis	Sydney waxbill	7
Aidemosyne modesta	Plum-headed finch	1
Alisteranus cinctus	Parson finch	1
Amadina fasciata	Cut-throat weaver finch	1
Amandava amandava	Strawberry finch	2
Diatropura procne	Giant whydah	3
Emblema picta	Painted finch	1
Estrilda astrild	Red-cared waxbill	5
Estrilda cinerea	Common waxbill	2
Euplectes franciscana	Bishop weaver	1
Euplectes orix	Red bishop weaver	4
Lonchura leucogastroides	Bengali finch	3
Lonchura malacca	Black-throated munia	5
Lonchura punctulata	Spice finch	2
Padda oryzivora	Java finch	28
Passer domesticus	House sparrow	2

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

BIRDS—Continued

PASSERIFORMES—continued

Scientific name	*Common name*	*Number*
Ploceidae—Continued		
Ploceus baya	Baya weaver	19
Ploceus vitellinus	Vitelline masked weaver	1
Poephila acuticauda	Long-tailed finch	1
Poephila gouldiae	Gouldian finch	3
Quelea quelea	Red-billed weaver	1
Sporaeginthus melpodus	Orange-cheeked waxbill	7
Steganopleura bichenovii	Bicheno's finch	1
Steganura pradisea	Paradise whydah	2
Taeniopygia castanotis	Zebra finch	30
Uracginthus bengalus	Cordon-bleu finch	1
Icteridae:		
Icterus giraudi	Giraud's oriole	3
Icterus icterus	Troupial	1
Molothrus ater	Cowbird	2
Notiopsar curaeus	Chilean blackbird	1
Quiscalus quiscula	Purple grackle	1
Xanthocephalus xanthocephalus	Yellow-headed blackbird	1
Thraupidae:		
Calospiza ruficapilla	Brown-headed tanager	1
Piranga rubra	Summer tanager	1
Ramphocelus carbo	Silver-beaked tanager	3
Ramphocelus dimidiatus	Crimson tanager	2
Ramphocelus flammigerus	Yellow tanager	1
Ramphocelus passerinii	Passerini's tanager	4
Thraupis cana	Blue tanager	1
Thraupis palmarum	Black-winged palm tanager	1
Fringillidae:		
Carpodacus mexicanus	Mexican house finch	3
Cayleyna picta	Painted finch	1
Cyanocompsa argentina	Argentine blue grosbeak	1
Junco hyemalis	Junco	1
Lophospingus pusillus	Black-crested finch	1
Paroaria cucullata	Brazilian cardinal	1
Paroaria gularis nigro-genis	Black-eared cardinal	1
Passerella iliaca	Fox sparrow	1
Passerina ciris	Painted bunting	1
Passerina cyanea	Indigo bunting	1
Phcucticus aureoventris	Black-and-yellow grosbeak	1
Poospiza torquata	Ringed warbling finch	2
Richmondena cardinalis	Cardinal	2
Serinus canarius	Canary	26
Serinus icterus	Green singing finch	1
Sicalis luteola	Saffron finch	9
Sporophila gutturalis	Yellow-billed seedeater	11
Sporophila melanocephala	Black-headed seedeater	2

REPTILES

RHYNCHOCEPHALIA

Sphenodontidae:		
Sphenodon punctatum	Tuatara	1

LORICATA

Crocodylidae:		
Alligator mississipiensis	Alligator	26
Alligator sinensis	Chinese alligator	2
Caiman sclerops	Spectacled caiman	20
Crocodylus acutus	American crocodile	4
Crocodylus cataphractus	Narrow-nosed crocodile	1
Crocodylus niloticus	African crocodile	2
Crocodylus porosus	Salt-water crocodile	1
Osteolaemus tetraspis	Broad-nosed crocodile	3

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

REPTILES—Continued

SQUAMATA

SAURIA

Scientific name	Common name	Number
Gekkonidae:		
Tarentola cubana	Gecko	1
Tarentola mauritanica	Egyptian gecko	2
Agamidae:		
Amphibolurus barbatus	Bearded lizard	1
Gerrhosauridae:		
Gerrhosaurus major	Greater African plated lizard	7
Zonosaurus ornatus	Ornate lizard	1
Iguanidae:		
Anolis carolinensis	Anolis, or false chameleon	5
Anolis equestris	Giant anolis	1
Conolophus subcristatus	Galapagos iguana	2
Cyclura macleayi	Cuban iguana	3
Iguana iguana	Common iguana	2
Phrynosoma cornutum	Horned lizard	1
Sceloporus clarkii	Clark's spiny lizard	2
Sceloporus undulatus	Pine or fence lizard	3
Helodermatidae:		
Heloderma horridum	Mexican beaded lizard	2
Heloderma suspectum	Gila monster	2
Varanidae:		
Varanus indicus	East Indies monitor	2
Varanus niloticus	African monitor	1
Varanus varius	Lace monitor	3
Teiidae:		
Tupinambis nigropunctatus	Black tegu	2
Tupinambis teguixin	Yellow tegu	2
Scincidae:		
Chalcides ocellatus	Skink	1
Chalcides sepsoides	Three-fingered skink	1
Egernia cunninghami	Cunningham's skink	1
Egernia luctuosa	Mourning skink	4
Egernia whitii	White's skink	11
Eremias mucronata	Mucronate sand lizard	2
Eumeces fasciatus	Blue-tailed skink	2
Scincus officinalis	Shovel-nosed skink	37
Tiliqua scincoides	Blue-tongued skink	1
Trachysaurus rugosus	Stump-tailed lizard	1
Chamaeleontidae:		
Chamaeleon jacksoni	Three-horned chameleon	7
Chamaeleon taitensis	Hornless chameleon	1
Anguidae:		
Gerrhonotus multicarinatus webbi	Alligator lizard	3
Ophisaurus apus	Old World legless lizard	3

SERPENTES

Boidae:		
Boa canina	Green tree boa	1
Constrictor constrictor	Boa constrictor	2
Constrictor imperator	Central American boa	10
Epicrates cenchria	Rainbow boa	4
Eryx jaculus	Blunt-tailed sand boa	7
Eryx thebaicus	Egyptian sharp-tailed sand boa	10
Eunectes murinus	Anaconda	15
Python molurus	Indian rock python	2
Python regius	Ball python	5
Python reticulatus	Regal python	5

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

REPTILES—Continued

SERPENTES—continued

Scientific name	*Common name*	*Number*
Colubridae:		
Acrochordus javanicus	Elephant trunk snake	1
Carphophis amoena	Worm snake	1
Chrysopelea ornata	Gliding tree snake	3
Coluber constrictor	Black snake	4
Coluber diadema	Diadem coluber	2
Coluber florulenta	Egyptian racer	2
Diadophis punctatus	Ring-necked snake	1
Drymarchon corais couperi	Indigo snake	5
Elaphe guttata	Corn snake (Albino)	1
Elaphe longissima	Aesculapian snake	2
Elaphe obsoleta confinis	Southern pilot snake	1
Elaphe obsoleta obsoleta	Pilot black snake	10
Lampropeltis doliata doliata	Scarlet king snake	1
Lampropeltis getulus californiae	Boyle's king snake	2
Lampropeltis getulus getulus	Chain or king snake	1
Lampropeltis getulus holbrooki	Speckled king snake	1
Lampropeltis getulus splendida	Sonoran king snake	2
Leptodeira annulata	Cat-eyed snake	1
Natrix natrix	European grass snake	2
Natrix sipedon sipedon	Water snake	9
Oxybelis acuminatus	Pike-head snake	1
Psammophis sibilans	Father-of-stripes	1
Ptyas mucosus	Indian rat snake	1
Thamnophis elegans	Arizona garter snake	1
Elapidae:		
Micrurus fulvius	Coral snake	2
Naja haje	Egyptian cobra	1
Naja hannah	King cobra	1
Naja melanoleuca	West African spitting cobra	1
Naja naja	Indian cobra	6
Naja nigricollis	Black-necked spitting cobra	1
Crotalidae:		
Ancistrodon piscivorus	Cottonmouth moccasin	2
Crotalus horridus	Timber rattlesnake	1
Crotalus viridis oreganus	Northern Pacific rattlesnake	16

TESTUDINATA

Chelydidae:		
Batrachemys nasuta	South American side-necked turtle.	2
Chelodina longicollis	Australian long-necked turtle	3
Chelys fimbriata	Matamata turtle	3
Hydraspis sp	Cagado or South American snake-necked turtle.	1
Hydromedusa tectifera	Small snake-necked turtle	2
Phrynops geoffroyana	Geoffroy's snake-necked turtle	1
Phrynops hilarii	Large snake-necked turtle	15
Platemys platycephala	Flat-headed turtle	1
Kinosternidae:		
Kinosternon subrubrum	Mud turtle	10
Sternotherus odoratus	Musk turtle	10
Chelydridae:		
Chelydra serpentina	Snapping turtle	10
Emydidae:		
Batagur baska	Indian fresh-water turtle	1
Chrysemys picta	Painted turtle	17
Clemmys guttata	Spotted turtle	20
Clemmys insculpta	Wood turtle	3
Cyclemys amboinensis	Kura kura box turtle	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

REPTILES—Continued

TESTUDINATA—continued

Scientific name	*Common name*	*Number*
Emydidae—Continued		
Emydura krefftii	Krefft's turtle	3
Emydura macquariae	Murray turtle	9
Emys orbicularis	European pond turtle	1
Graptemys barbouri	Barbour's turtle	7
Graptemys geographica	Map turtle	9
Graptemys pseudogeographica	False map turtle	2
Malaclemys centrata	Diamond-back turtle	5
Pelusios nigricans	African black water turtle	2
Pseudemys concinna	Cooter	1
Pseudemys elegans	Mobile turtle	12
Pseudemys floridana	Florida water turtle	8
Pseudemys ornata	Central American turtle	3
Pseudemys rubriventris	Red-bellied turtle	2
Pseudemys scripta	Red-lined turtle	10
Pseudemys troostii	Cumberland turtle	2
Terrapene carolina	Box turtle	50
Terrapene triunguis	Three-toed box turtle	6
Testudo ephippium	Duncan Island turtle	1
Pelomedusidae:		
Pelomedusa galeata	African water turtle	1
Pelusios nigricans	African water turtle	8
Pelusios sinuatus	Yellow-bellied water turtle	8
Testudinidae:		
Gopherus polyphemus	Gopher turtle	3
Testudo porteri	Seymour Island turtle	1
Testudo tabulata	South American turtle	1
Testudo vicina	Albemarle Island turtle	5
Trionychidae:		
Trionyx ferox	Soft-shelled turtle	9
Trionyx triunguis	West African soft-shelled turtle	2

AMPHIBIANS

CAUDATA

Salamandridae:		
Diemictylus viridescens	Red-spotted newt (of the United States).	1
Triturus pyrrhogaster	Red Japanese newt	11
Amphiumidae:		
Amphiuma means	Congo "eel"	1
Ambystomidae:		
Ambystoma maculatum	Spotted salamander	1
Cryptobranchidae:		
Megalobatrachus japonicus	Giant Japanese salamander	3

SALIENTIA

Dendrobatidae:		
Atelopus varius zeteki	Yellow atelopus	13
Dendrobates tinctoria	Arrow-poison frog	9
Bufonidae:		
Bufo americanus	Common toad	30
Bufo marinus	Marine toad	9
Bufo parocnemis	Rococo toad	2
Bufo quercicus	Oak toad	1
Bufo viridis	European green toad	6
Discoglossidae:		
Alytes obstetricans	Midwife toad	3
Bombina variegata	Yellow-bellied toad	1

ANIMALS IN THE COLLECTION ON JUNE 30, 1954—Continued

AMPHIBIANS—Continued

SALIENTIA—continued

Scientific name	*Common name*	*Number*
Leptodactylidae:		
Cerotophrys calcarata	Colombian horned frog	2
Ceratophrys ornata	Argentine horned frog	2
Pipidae:		
Xenopus mülleri	Müller's clawed frog	5
Ranidae:		
Rana adspersa	African bull frog	13
Rana catesbeiana	Bull frog	3
Rana clamitans	Green frog	2
Rana palustris	Pickerel frog	2
Rana pipiens	Leopard frog	10

FISHES

Aequidens pulcher	Blue acara	1
Alepidomus evermanni	Cuban glassfish	6
Anabas testudineus	Climbing perch	3
Anoptichthys jordani	Blind characin	2
Apistogramma ramirezi	Butterfly cichlid	1
Astronotus ocellatus	Peacock cichlid	10
Barbus everetti	Clown barb	2
Barbus oligolepis		2
Barbus tetrazona		2
Brachydanio albolineatus	Pearl danio	7
Brachygobius xanthozonus	Bumblebee-fish	5
Corydoras sp	South American catfish	1
Elassoma evergladei	Pygmy sunfish	2
Electrophorus electricus	Electric eel	1
Haplochromis strigigena	Egyptian mouthbreeder	1
Heterandria formosa	Mosquitofish	2
Hyphessobrycon innesi	Neon tetra	3
Lebistes reticulatus	Guppy	100
	Lyretail guppy	10
Lepidosiren paradoxa	South American lungfish	1
Otocinclus affinis		2
Platypoecilus maculatus	Red moon	5
Pristella riddlei		2
Protopterus annectans	African lungfish	2
Pterophyllum eimekei	Scalare or angelfish	1
Quintana atrizona	Cuban mosquitofish	3
Serrasalmus ternetzi	Piranha	1
Sternarchella schotti	Knife-fish	2
Tanichthys albonubes	White Cloud Mountain fish	7
Trichopsis pumilus		2
Xiphophorus helleri	Swordtail	4
	Red swordtail	3

ARACHNIDS

Eurypelma sp	Tarantula	1
Latrodectus mactans	Black-widow spider	2

INSECTS

Blabera sp	Giant cockroach	100

MOLLUSKS

Achatina achatina	Giant land snail	1

STATUS OF THE COLLECTION

Class	Species or subspecies	Individuals	Class	Species or subspecies	Individuals
Mammals	231	792	Arachnids	2	3
Birds	305	1,163	Insects	1	100
Reptiles	127	596	Mollusks	1	1
Amphibians	22	130			
Fish	32	195	Total	723	2,980

Animals on hand July 1, 1953	2,741
Accessions during the year	2,250
Total number of animals in collection during the year	4,991
Removals for various reasons such as death, exchanges, return of animals on deposit, etc. (This includes a total of 302 miscellaneous animals enumerated on page 96.)	2,011
In collection on June 30, 1954	2,980

Respectfully submitted.

W. M. Mann, *Director.*

Dr. Leonard Carmichael,
Secretary, Smithsonian Institution.

Report on the Canal Zone Biological Area

Sir: It gives me pleasure to present herewith the annual report of the Canal Zone Biological Area for the fiscal year ended June 30, 1954.

About mid-August 1953 the resident manager became critically ill and was obliged to be absent from the island until the middle of March 1954. It was most fortunate that he was able to secure the aid of his former associate, Mrs. Adela Gomez, who was well informed regarding the island set-up and routine, scientists, and visitors. Mrs. Gomez took over, despite demanding home and family duties, and through her ability and thorough understanding of the work, she did a heroic job.

It was also most fortunate for all concerned to have the assistance of Cleveland C. Soper, in charge of Eastman Kodak Company's Tropical Research Laboratory. Not only was he most generous with his time, but his advice was invaluable. Had it not been for his technical knowledge, the island would have been blacked out and there would have been no refrigeration for lack of current when the two diesel units were overhauled. In recognition of his invaluable help, the Smithsonian Institution tendered him an appointment as research associate.

BUILDINGS AND EQUIPMENT

The two 15-kv. diesel generators received, in addition to routine maintenance inspections and adjustments, an annual overhaul.

Posts for the overhead electric-current distribution line were installed. Two wires strung to these furnish 110 volts, 60 cycles. A third wire will provide 220 volts 24 hours daily. All posts with feeders for the various buildings have fuse boxes installed.

The new large concrete water tank west of the new laboratory building, which receives water from the roof of this building, has been finished and is in use. Water is pumped from it into the large tank on Snyder-Molino from which there is a good gravity flow. A new 2-hp. motor was purchased for the old water pump, which is still serviceable.

Each year the island dock has had to be extended because of increased silting. Plans have been made and preliminary work started to remedy this situation by making a trail along the south shore of the cove to deep water.

Minor repairs were made to the two launches and their engines.

All buildings except the old Chapman house were gone over, and all except the trail-end houses are in good shape. Of the latter, only the Drayton and the Fuertes houses are in good condition. The Chapman house, if repaired, can be used for five more years. The iron beds in all dormitories should be repainted. All trails were gone over and fallen markers replaced. The trails are in good condition.

MOST URGENT NEEDS

Completion of the new large building is imperative. This will house laboratories, a dark room, the library, herbarium, indexes, microscopes, cameras, sterilizers, laboratory chemicals, reagents, and glassware. Some progress has been made, but there is still much to be done. Electric wiring and fixtures must be installed, water piped in, and sinks provided. Tables, shelves, and chairs should be furnished, metal bookcases purchased for the library, and six dehumidifiers must be obtained. Plans provide for a large enough dry room to dry out mattresses periodically. Another dry room is needed on the upper floor of the old large building to keep laundry and bedding from mildewing.

When the library is moved into the new building, the Haskins fireproof building will be converted into a kitchen and kitchen storeroom, which will eliminate the fire hazard ever present in the wooden structure now housing the kitchen. A new electric stove has been purchased and will be installed as soon as the 220-volt line is available. An electric water heater will be purchased when funds are available.

SCIENTISTS AND THEIR STUDIES

The primary purpose of the Canal Zone Biological Area is to provide a safe and accessible area for scientific research in the lower humid tropics in the Americas. Probably nowhere else in the world can be found the combination of unspoiled tropical jungle and healthful laboratory surroundings. Here scientists find a profusion of plants and animals and are able to carry on a wide variety of special studies.

During the fiscal year 1954, 22 scientists came to the island. The high cost of transportation prevents many from coming, and also, in many cases curtails the length of stay. A list of the season's 22 investigators, with a brief summary of their special interests, follows:

Investigator	*Principal interest or special study*
Ansley, Dr. Hudson, Johns Hopkins University.	Preservation of material for spermatogenesis studies of certain pentatomids, scutigerids, and related forms.
Carr, Dr. Archie, University of Florida.	Herpetology and tropical ecology.
Elliott, Dr. Alfred, University of Michigan.	Extensive collections of fresh-water ciliates (*Tetrahymena pyriformis*) for possible biological mutants.
Everest, F. Alton, Moody Institute of Science, Los Angeles, Calif.	With Edwin C. Udey, to study and appraise the broad features of the photographic program to be developed by Udey.
Grinnell, Dr. and Mrs. Laurence I., Ithaca, N. Y.	Ecological studies of birds, with long series of photographs.
Hodgson, Dr. Edward S., Barnard College.	Studies for Office of Naval Research.
Lundy, William E., Panama Canal Company.	Detailed studies of mammals, birds, and insects, for future accounts in the magazine Natural History.
Luti, Ricardo, Argentina.	Plant ecology.
Mena, Anselmo, Canal Zone.	Assistance to Dr. W. P. Woodring.
Morris, Robert C., Gulfport Station of U. S. Forest Service.	Periodic examination of the international and other termite tests started by Snyder and Zetek, and those by Kowal and Morris.
Pierson, Dr. and Mrs. H. L., Hampton, N. H.	Photography of plant and animal life and natural-history studies.
Soper, Cleveland C., Tropical Research Laboratory, Eastman Kodak Co.	Deterioration and corrosion of photographic equipment and supplies.
Treichel, Dr. George W., University of California.	Geographical and botanical field work and mapping.
Udey, Edwin C., Moody Institute of Science, Los Angeles, Calif.	Motion and still photography, both color and black and white, covering the behavior of the island animal and plant life, documented for a lecture film on Barro Colorado Island.
Wagner, Dr. and Mrs. Richard, Cambridge, Mass.	Photographic study of plants, birds, mammals, and habitats.
Weatherwax, Dr. Paul, Indiana University.	Study of the grasses of Barro Colorado.
Wetmore, Dr. and Mrs. Alexander, Smithsonian Institution.	Inspection of the physical plant, and continuation of studies of the birds of the island.
Woodring, Dr. and Mrs. W. P., U. S. Geological Survey.	Stratigraphic relations of the fossiliferous beds of early Tertiary age in Gatun Lake near Barro Colorado, and new fossil deposits of the island; progress on a new map of the island, and manuscript on the geology of Barro Colorado.

VISITORS

The number of visitors dropped to about three-fourths that of last year. Most of them came in small groups, and quite a number stayed overnight or for a few days. Among these were Boy Scouts, Girl Scouts, and photography clubs; groups from schools in Panama City, Colon, and elsewhere; from colleges, and from the University of Panama. There were also a number of groups from the Armed Forces, the United States Embassy in Panama, many technical and specialized missions, and branches of the Point 4 Program. There were many scientists returning from other missions and who had only a day or two on Barro Colorado. Among the most distinguished and enthusiastic visitors were King Leopold and his wife, Her Royal Highness Princess Liliane, of Belgium.

RAINFALL

In 1953, during the dry season (January to April) rains of 0.01 inch or more fell on 48 days (165 hours) and on 194 days during the 8 months of the wet season.

Rainfall was 1.90 inches below the 29-year station average, as compared to 9.26 inches last year—an excess of 5.37 inches for the 4-month dry season, and a deficiency of 7.27 inches for the 8-month wet season. February was the driest month, 0.69 inch, and November the wettest, 19.28 inches.

TABLE 1.—*Annual rainfall, Barro Colorado Island, C. Z.*

Year	Total inches	Station average	Year	Total inches	Station average
1925	104. 37	-------	1940	86. 51	109. 43
1926	118. 22	113. 56	1941	91. 82	108. 41
1927	116. 36	114. 68	1942	111. 10	108. 55
1928	101. 52	111. 35	1943	120. 29	109. 20
1929	87. 84	106. 56	1944	111. 96	109. 30
1930	76. 57	101. 51	1945	120. 42	109. 84
1931	123. 30	104. 69	1946	87. 38	108. 81
1932	113. 52	105. 76	1947	77. 92	107. 49
1933	101. 73	105. 32	1948	83. 16	106. 43
1934	122. 42	107. 04	1949	114. 86	106. 76
1935	143. 42	110. 35	1950	114. 51	107. 07
1936	93. 88	108. 98	1951	112. 72	107. 28
1937	124. 13	110. 12	1952	97. 68	106. 94
1938	117. 09	110. 62	1953	104. 97	106. 87
1939	115. 47	110. 94			

TABLE 2.—*Comparison of 1952 and 1953 rainfall, Barro Colorado Island, C. Z. (inches)*

Month	Total		Station average	Years of record	Excess or deficiency	Accumulated excess or deficiency
	1952	1953				
January	2.40	4.30	1.86	28	+2.44	+2.44
February	.39	.69	1.24	28	−0.55	+1.89
March	.11	1.20	1.20	28		+1.89
April	5.46	6.64	3.16	29	+3.48	+5.37
May	12.39	9.21	10.83	29	−1.62	+3.75
June	11.76	3.81	11.14	29	−7.33	−3.58
July	6.01	15.93	11.44	29	+4.49	+0.91
August	9.11	15.60	12.28	29	+3.32	+4.23
September	11.13	5.70	9.91	29	−4.21	+0.02
October	16.96	18.27	13.68	29	+4.59	+4.61
November	9.50	19.28	19.11	29	+0.17	+4.78
December	12.46	4.34	11.02	29	−6.68	−1.90
Year	97.68	104.97	106.87			
Dry season	8.36	12.83	7.46			
Wet season	89.32	92.14	99.41			

The maximum yearly rainfall of record on the island was 143.42 inches and the minimum 76.57 inches. The maximum of record for short periods were as follows: 5 minutes, 1.30 inches; 10 minutes, 1.65 inches; 1 hour, 4.11 inches; 2 hours, 4.81 inches; 24 hours, 10.48 inches.

During 1953 the maximums were: 5 minutes, 0.52 inch; 10 minutes, 1.01 inches; 1 hour, 2.65 inches; 2 hours, 3.32 inches; 24 hours, 4.85 inches.

FINANCIAL SUPPORT

The rates for scientists and visitors now in effect are $3 a day per person for 1-day visitors, $4 a full day for scientists from institutions that support the laboratory through table subscriptions, and $5 a full day for all others. A 1-day visit includes the use of the launch to and from the island, the noon meal, and the guide in the morning. A full day for scientists includes three meals and lodging.

The following institutions contributed their support to the laboratory through the payment of table subscriptions or grants:

Research Corporation	$15,000
Eastman Kodak Co	1,000
New York Zoological Society	300
American Museum of Natural History	300
Smithsonian Institution	300

[The Institution provides other funds as needed.]

It is most gratifying to report again donations from Dr. Eugene Eisenmann of New York and Dr. Herbert F. Schwarz of the American Museum of Natural History.

Those contemplating a visit to this unique spot of the Americas should communicate with the Secretary of the Smithsonian Institu-

tion, Washington 25, D. C., or with the Resident Manager of the Canal Zone Biological Area, Drawer C, Balboa, Canal Zone.

ACKNOWLEDGMENTS

Thanks are due to the Panama Canal Company, particularly the Dredging and Commissary Divisions and the Storehouses; the Canal Zone Government, especially the Police Division; the officials and employees of the Panama Railroad for their wholehearted cooperation; and also to Mr. Soper, Dr. Paul Swift, and the staff of the Tropical Research Laboratory of Eastman Kodak Co. Without their generous and unfailing assistance, the Area could not function so successfully.

Respectfully submitted.

JAMES ZETEK, *Resident Manager.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the International Exchange Service

SIR: I have the honor to submit the following report on the activities of the International Exchange Service for the fiscal year ended June 30, 1954:

The Smithsonian Institution is the official United States agency for the exchange with other nations of governmental, scientific, and literary publications. The International Exchange Service, initiated by the Smithsonian Institution in the early years of its existence for the interchange of scientific publications between learned societies and individuals in the United States and those of foreign countries, serves as a means of developing and executing in part the broad and comprehensive objective, "the diffusion of knowledge." It was later designated by the United States Government as the agency for the transmission of official documents to selected depositories throughout the world, and it continues to execute the exchanges pursuant to conventions, treaties, and other international agreements.

Although the weight of the packages received during the year for transmission decreased by 57,782 pounds to the total of 797,320 pounds, the number of packages decreased by only 1,429 to the total of 1,020,509. The average weight of the individual package was only 12.49 ounces, an indication that the publications now being transmitted are current publications rather than large lots of accumulated publications.

The publications received from foreign sources for addressees in the United States and from domestic sources for shipment abroad are classified as shown in the following table:

Classification	Packages		Weight	
	Number	*Number*	*Pounds*	*Pounds*
United States parliamentary documents sent abroad	523, 314		255, 597	
Publications received in return for parliamentary documents		11, 148		17, 040
United States departmental documents sent abroad	241, 139		185, 943	
Publications received in return for departmental documents		12, 287		24, 785
Miscellaneous scientific and literary publications sent abroad	174, 033		215, 652	
Miscellaneous scientific and literary publications received from abroad for distribution in the United States		58, 588		98, 303
Total	938, 486	82, 023	657, 192	140, 128
Grand total	1, 020, 509		797, 320	

The packages of publications are forwarded to the exchange bureaus of foreign countries by freight or, where shipment by such means is impractical, to the foreign addressees by direct mail. Distribution in the United States of the publications received from foreign exchange bureaus is accomplished primarily by mail, but by other means when more economical. The number of boxes shipped to the foreign exchange bureaus was 3,566 or 917 more than for the previous year. Of these boxes 942 were for depositories of full sets of United States Government documents, these publications being furnished in exchange for the official publications of foreign governments which are received for deposit in the Library of Congress. The number of packages forwarded by mail and by means other than freight was 209,865.

There was allocated to the International Exchange Service for transportation $49,600. With this amount it was possible to effect the transportation of 924,018 pounds. This figure represents 126,698 pounds over the weight of the publications received during the year and comprised publications that could not be shipped in the previous fiscal year owing to lack of funds.

Slight increases occurred in both freight and postal rates during the year.

Total outgoing correspondence was 2,454 letters, exclusive of information copies.

No shipments are being made to China, North Korea, or Rumania. Publications intended for addresses in Formosa and formerly sent through the Chinese Exchange Bureau at Nanking are now forwarded by direct mail.

Regulations of the Bureau of Foreign Commerce, Department of Commerce, provide that each package of publications exported bear a general license symbol and a legend, "Export License Not Required," and the International Exchange Service accepts for transmission to foreign destinations only those packages of publications to which the general license symbol and legend have been applied by the consignor.

FOREIGN DEPOSITORIES OF GOVERNMENTAL DOCUMENTS

The number of sets of United States official publications received by the Exchange Service for transmission abroad in return for the official publications sent by foreign governments for deposit in the Library of Congress is now 105 (62 full and 43 partial sets), listed below. Changes that occurred during the year are shown in the footnotes.

DEPOSITORIES OF FULL SETS

ARGENTINA: División Biblioteca, Ministerio de Relaciones Exteriores y Culto, Buenos Aires.
AUSTRALIA: Commonwealth Parliament and National Library, Canberra.
NEW SOUTH WALES: Public Library of New South Wales, Sydney.
QUEENSLAND: Parliamentary Library, Brisbane.
SOUTH AUSTRALIA: Public Library of South Australia, Adelaide.
TASMANIA: Parliamentary Library, Hobart.
VICTORIA: Public Library of Victoria, Melbourne.
WESTERN AUSTRALIA: Public Library of Western Australia, Perth.
AUSTRIA: Administrative Library, Federal Chancellery, Vienna.
BELGIUM: Bibliothèque Royale, Bruxelles.
BRAZIL: Biblioteca Nacional, Rio de Janeiro.
BULGARIA: Bulgarian Bibliographical Institute, Sofia.
BURMA: Government Book Depot, Rangoon.
CANADA: Library of Parliament, Ottawa.
MANITOBA: Provincial Library, Winnipeg.
ONTARIO: Legislative Library, Toronto.
QUEBEC: Library of the Legislature of the Province of Quebec.
CEYLON: Department of Information, Government of Ceylon, Colombo.
CHILE: Biblioteca Nacional, Santiago.
CHINA: Ministry of Education, National Library, Nanking, China.[1]
PEIPING: National Library of Peiping.[1]
COLOMBIA: Biblioteca Nacional, Bogotá.
COSTA RICA: Biblioteca Nacional, San José.
CUBA: Ministerio de Estado, Canje Internacional, Habana.
CZECHOSLOVAKIA: National and University Library, Prague.
DENMARK: Institut Danios des échanges Internationaux, Copenhagen.
EGYPT: Bureau des Publications, Ministère des Finances, Cairo.
FINLAND: Parliamentary Library, Helsinki.
FRANCE: Bibliothèque Nationale, Paris.
GERMANY: Offentliche Wissenschaftliche Biblothek, Berlin.
Parliamentary Library, Bonn.
Free University of Berlin, Berlin.
GREAT BRITAIN:
ENGLAND: British Museum, London.
LONDON: London School of Economics and Political Science. (Depository of the London County Council.)
HUNGARY: Library of Parliament, Budapest.
INDIA: National Library, Calcutta.
Central Secretariat Library, New Delhi.
INDONESIA: Ministry for Foreign Affairs, Djakarta.
IRELAND: National Library of Ireland, Dublin.
ISRAEL: Government Archives and Library, Hakirya.
ITALY: Ministerio della Publica Istruzione, Rome.
JAPAN: National Diet Library, Tokyo.[2]
MEXICO: Secretaría de Relaciones Exteriores, Departmento de Información para el Extranjero, México, D. F.
NETHERLANDS: Royal Library, The Hague.
NEW ZEALAND: General Assembly Library, Wellington.
NORWAY: Utenriksdepartmentets Bibliothek, Oslo.

[1] Shipment suspended.
[2] Receives two sets.

PERU: Sección de Propaganda y Publicaciones, Ministerio de Relaciones Exteriores, Lima.
PHILIPPINES: Bureau of Public Libraries, Department of Education, Manila.
POLAND: Bibliothèque Nacionale, Warsaw.
PORTUGAL: Biblioteca Nacional, Lisbon.
SPAIN: Biblioteca Nacional, Madrid.
SWEDEN: Kungliga Biblioteket, Stockholm.
SWITZERLAND: Bibliothèque Centrale Fédérale, Berne.
TURKEY: Department of Printing and Engraving, Ministry of Education, Istanbul.
UNION OF SOUTH AFRICA: State Library, Pretoria, Transvaal.
UNION OF SOVIET SOCIALIST REPUBLICS: All-Union Lenin Library, Moscow 115.
UNITED NATIONS: Library of the United Nations, Geneva, Switerland.
URUGUAY: Oficina de Canje Internacional de Publicaciones, Montevideo.
VENEZUELA: Biblioteca Nacional, Caracas.
YUGOSLAVIA: Bibliografski Institut, Belgrade.[3]

DEPOSITORIES OF PARTIAL SETS

AFGHANISTAN: Library of the Afghan Academy, Kabul.
ANGLO-EGYPTIAN SUDAN: Gordon Memorial College, Khartoum.
BOLIVIA: Biblioteca del Ministerio de Relaciones Exteriores y Culto, La Paz.
BRAZIL:
MINAS GERAIS: Directoria Geral de Estatistica em Minas, Belo Horizonte.
BRITISH GUIANA: Government Secretary's Office, Georgetown, Demerara.
CANADA:
ALBERTA: Provincial Library, Edmonton.
BRITISH COULMBIA: Provincial Library, Victoria.
NEW BRUNSWICK: Legislative Library, Fredericton.
NEWFOUNDLAND: Department of Provincial Affairs, St. John's.
NOVA SCOTIA: Provincial Secretary of Nova Scotia, Halifax.
SASKATCHEWAN: Legislative Library, Regina.
DOMINICAN REPUBLIC: Biblioteca de la Universidad de Santo Domingo, Ciudad Trujillo.
ECUADOR: Biblioteca Nacional, Quito.
EL SALVADOR:
Biblioteca Nacional, San Salvador.
Ministerio de Relaciones Exteriores, San Salvador.
GREECE: National Library, Athens.
GUATEMALA: Biblioteca Nacional, Guatemala.
HAITI: Bibliothèque Nationale, Port-au-Prince.
HONDURAS:
Biblioteca y Archivo Nacionales, Tegucigalpa.
Ministerio de Relaciones Exteriores, Tegucigalpa.
ICELAND: National Library, Reykjavik.
INDIA:
BIHAR AND ORISSA: Revenue Department, Patna.
BOMBAY: Undersecretary to the Government of Bombay, General Department, Bombay.
UNITED PROVINCES OF AGRA AND OUDH:
University of Allahabad, Allahabad.
Secretariat Library, Uttar Pradesh, Lucknow.
WEST BENGAL: Library, West Bengal Legislative Secretariat, Assembly House, Calcutta.

IRAN: Imperial Ministry of Education, Tehran.
IRAQ: Public Library, Baghdad.
JAMAICA: Colonial Secretary, Kingston.
University College of the West Indies, St. Andrew.
LEBANON: American University of Beirut, Beirut.
LIBERIA: Department of State, Monrovia.
MALAYA: Federal Secretariat, Federation of Malaya, Kuala Lumpur.
MALTA: Minister for the Treasury, Valleta.
NICARAGUA: Ministerio de Relaciones Exteriores, Managua.
PAKISTAN: Chief Secretary to the Government of Punjab, Lahore.
Central Secretariat Library, Karachi.[3]
PANAMA: Ministerio de Relaciones Exteriores, Panamá.
PARAGUAY: Ministerio de Relaciones Exteriores, Sección Biblioteca, Asunción.
SCOTLAND: National Library of Scotland, Edinburgh.
SIAM: National Library. Bangkok.
SINGAPORE: Chief Secretary, Government Offices, Singapore.
VATICAN CITY: Biblioteca Apostolica Vaticana, Vatican City, Italy.

INTERPARLIAMENTARY EXCHANGE OF THE OFFICIAL JOURNALS

There are now being sent abroad 90 copies of the Federal Register and 104 copies of the Congressional Record. This is a decrease from the preceding year of 2 copies of the Federal Register and an increase of 2 copies of the Congressional Record. The countries to which these journals are being forwarded are given in the following list:

DEPOSITORIES OF CONGRESSIONAL RECORD AND FEDERAL REGISTER

ARGENTINA:
Biblioteca del Congreso Nacional, Buenos Aires.
Biblioteca del Poder Judicial, Mendoza.[4]
Boletín Oficial de la República Argentina, Ministerio de Justica e Finstrucción Pública, Buenos Aires.
Cámara de Diputados Oficina de Información Parlamentaria, Buenos Aires.
AUSTRALIA:
Commonwealth Parliament and National Library, Canberra.
NEW SOUTH WALES: Library of Parliament of New South Wales, Sydney.
QUEENSLAND: Chief Secretary's Office, Brisbane.
VICTORIA: Public Library of Victoria, Melbourne.[4]
WESTERN AUSTRALIA: Library of Parliament of Western Australia, Perth.
BRAZIL:
Biblioteca da Camera dos Deputados, Rio de Janeiro.
Secretaria de Presidencia, Rio de Janeiro.[5]
AMAZONAS: Archivo, Biblioteca e Imprensa Publica, Manáos.
BAHIA: Governador do Estado da Bahia, São Salvador.
ESPIRITO SANTO: Presidencia do Estado do Espirito Santo, Victoria.
RIO GRANDE DO SUL: Imprensa Oficial do Estado, Porto Alegre.
SÃO PAULO: Imprensa Oficial do Estada, São Paulo.
SERGIPE: Biblioteca Pública do Estado de Sergipe, Aracajú.
BRITISH HONDURAS: Colonial Secretary, Belize.

[3] Reduced from full to partial depository during year.
[4] Federal Register only.
[5] Congressional Record only.

CANADA:
Library of Parliament, Ottawa.
Clerk of the Senate, Houses of Parliament, Ottawa.
CEYLON: Ceylon Ministry of Defense and External Affairs, Colombo.[5]
CHINA:
Legislative Yuan, Taipei, Taiwan.[5]
Taiwan Provincial Government, Taipei, Taiwan.
CUBA:
Biblioteca del Capitolio, Habana
Biblioteca Pública Panamericana, Habana.[4]
Biblioteca Martí, Cámara de Representantes, Habana.
CZECHOSLOVAKIA: Library of the Czechoslovak National Assembly, Prague.[5]
EGYPT: Ministry of Foreign Affairs, Egyptian Government, Cairo.[6]
EL SALVADOR: Library, National Assembly, San Salvador.
FRANCE:
Bibliothèque Assemblée Nationale, Paris.
Bibliothèque Conseil de la République, Paris.
Library, Organization for European Economic Cooperation, Paris.[5]
Publiques de l'Institut de Droit Comparé, Université de Paris, Paris.[4]
Research Department, Council of Europe, Strasbourg.[5]
Service de la Documentation Étrangère, Assemblée Nationale, Paris.[5]
GERMANY:
Amerika-Institut der Universität München, München.[5]
Archiv, Deutscher Bundesrat, Bonn.
Bibliothek der Instituts für Weltwirtschaft an der Universität Kiel, Kiel-Wik.
Bibliothek Hessischer Landtag, Wiesbaden.[5]
Der Bayrische Landtag, Munich.[5 5]
Deutscher Bundesrat, Bonn.[5]
Deutscher Bundestag, Bonn.[5]
GOLD COAST: Chief Secretary's Office, Accra.[5 7]
GREAT BRITAIN:
Department of Printed Books, British Museum, London.[5]
House of Commons Library, London.[5]
Printed Library of the Foreign Office, London.
Royal Institute of International Affairs, London[5]
GREECE: Bibliothèque, Chambre des Députés Hellénque, Athens.
GUATEMALA: Biblioteca de la Asamblea Legislativa, Guatemala.
HAITI: Bibliothèque Nationale, Port-au-Prince.
HONDURAS: Biblioteca del Congreso Nacional, Tegucigalpa.
INDIA:
Civil Secretariat Library, Lucknow, United Provinces.[4]
Indian Council of World Affairs, New Delhi.[5]
Jammu and Kashmir Constituent Assembly, Srinagar.[5 7]
Legislative Assembly, Government of Assam, Shillong.[5 7]
Legislative Assembly Library, Lucknow, United Provinces.
Legislative Assembly Library, Trivandrum.[6]
Legislative Department, Simla.
Parliament Library, New Delhi.[5]
Servants of India Society, Poona.[5]

[6] Three copies.
[7] Added during year.

IRELAND: Dail Eireann, Dublin.
ISRAEL: Library of the Knesset, Jerusalem.
ITALY:
Biblioteca Camera dei Deputati, Rome.
Biblioteca del Senato della Republica, Rome.
European Office, Food and Agriculture Organization of the United Nations Rome.[4]
International Institute for the Unification of Private Law, Rome.[4]
JAPAN: Library of the National Diet, Tokyo.
KOREA: Secretary General, National Assembly, Pusan.
LUXEMBOURG: Assemblée Commune de la C. E. C. A., Luxembourg.
MEXICO:
Dirección General Información, Secretaría de Gobernación, México, D. F.
Biblioteca Benjamin Franklin, México, D. F.
AGUASCALIENTES: Gobernador del Estado de Aguascalientes, Aguascalientes.
BAJA CALIFORNIA: Gobernador del Distrito Norte, Mexicali.
CAMPECHE: Gobernador del Estado de Campeche, Campeche.
CHIAPAS: Gobernador del Estado de Chiapas, Tuxtla Gutiérrez.
CHIHUAHUA: Gobernador del Estado de Chihuahua, Chihuahua.
COAHUILA: Periódico Oficial del Estado de Coahuila, Palacio de Gobierno, Saltillo.
COLIMA: Gobernador del Estado de Colima, Colima.
DURANGO: Gobernador Constitucional del Estado de Durango, Durango.
GUANAJUATO: Secretaría General de Gobierno del Estado, Guanajuato.
GUERRERO: Gobernador del Estado de Guerrero, Chilpancingo.
JALISCO: Biblioteca del Estado, Guadalajara.
MÉXICO: Gaceta del Gobierno, Toluca.
MICHOACÁN: Secretaría General de Gobierno del Estado de Michoacán, Morelia.
MORELOS: Palacio de Gobierno, Cuernavaca.
NAYARIT: Gobernador de Nayarit, Tepic.
NUEVO LEÓN: Biblioteca del Estado, Monterrey.
OAXACA: Periódico Oficial, Palacia de Gobierno, Oaxaca.
PUEBLA: Secretaría General de Gobierno, Puebla.
QUERÉTARO: Secretaría General de Gobierno, Sección de Archivo, Querétaro.
SAN LUIS POTOSÍ: Congreso del Estado, San Luis Potosí.
SINALOA: Gobernador del Estado de Sinaloa, Culiacán.
SONORA: Gobernador del Estado de Sonora, Hermosillo.
TABASCO: Secretaría de Gobierno, Sessión 3a, Ramo de Prensa, Villahermosa.
TAMAULIPAS: Secretaría General de Gobierno, Victoria.
TLAXCALA: Secretaría de Gobierno del Estado, Tlaxcala.
VERACRUZ: Gobernador del Estado de Veracruz, Departamento de Gobernación y Justicia, Jalapa.
YUCATÁN: Gobernador del Estado de Yucatán, Mérida.
NETHERLANDS: Koninklijke Bibliotheek, The Hague.[4]
NEW ZEALAND: General Assembly Library, Wellington.
NORWAY: Library of the Norwegian Parliament, Oslo.
PAKISTAN: Punjab Legislative Assembly Department, Lahore.
PANAMA: Biblioteca Nacional, Panama City.[5]
PERU: Cámara de Diputados, Lima.
POLAND: Ministry of Justice, Warsaw.[4]
PORTUGAL: Secretaria de Assembla National, Lisbon.[5]
PORTUGUESE TIMOR: Repartição Central de Administração Civil, Dili.[4]

SWITZERLAND: Bibliothèque, Bureau International du Travail, Geneva.[4]
International Labor Office, Geneva.[4 8]
Library, United Nations, Geneva.
UNION OF SOUTH AFRICA:
CAPE OF GOOD HOPE: Library of Parliament, Cape Town.
TRANSVAAL: State Library, Pretoria.
UNION OF SOVIET SOCIALIST REPUBLICS: Fundamental'niia Biblioteka Obschestvennykh Nauk, Moscow.[5]
URUGUAY: Diario Oficial, Calle Florida 1178, Montevideo.
VENEZUELAS Biblioteca del Congreso, Caracas

FOREIGN EXCHANGE SERVICES

Exchange publications for addresses in the countries listed below are forwarded by freight to the exchange services of those countries. Exchange publications for addresses in other countries are forwarded directly by mail.

LIST OF EXCHANGE SERVICES

AUSTRIA: Australian National Library, Vienna.
BELGIUM: Service des Échanges Internationaux, Bibliothèque Royale de Belgique, Bruxelles.
CHINA: Bureau of International Exchange, National Central Library, Nanking.[1]
CZECHOSLOVAKIA: Bureau of International Exchanges, National and University Library, Prague.
DENMARK: Institut Danois des Échanges Internationaux, Bibliothèque Royale, Copenhagen K.
EGYPT: Government Press, Publications Office, Bulaq, Cairo.
FINLAND: Delegation of the Scientific Societies, Snellmaninkatu 9–11, Helsinki.
FRANCE: Service des Échanges Internationaux, Bibliothèque Nationale, 58 Rue de Richelieu, Paris.
GERMANY: Notgemeinschaft der Deutschen Wissenschaft, Bad Godesberg.
GREAT BRITAIN AND IRELAND: Wheldon & Wesley, 83/84 Berwick Street, London, W. 1.[9]
HUNGARY: National Library, Széchényi, Budapest.[10]
INDIA: Superintendent of Government Printing and Stationery, Bombay.
INDONESIA: Department of Cultural Affairs and Education, Djakarta.
ISRAEL: Jewish National and University Library, Jerusalem.
ITALY: Ufficio degli Scambi Internazionali, Ministero della Publica Istruzione, Rome.
JAPAN: Division of International Affairs, National Diet Library, Tokyo.
NETHERLANDS: International Exchange Bureau of the Netherlands, Royal Library, The Hague.
NEW SOUTH WALES: Public Library of New South Wales, Sydney.
NEW ZEALAND: General Assembly Library, Wellington.
NORWAY: Service Norvégien des Échanges Internationaux, Bibliothèque de l'Université Royale, Oslo.
PHILIPPINES: Bureau of Public Libraries, Department of Education, Manila.
POLAND: Service Polonais des Échanges Internationaux, Bibliothèque Nationale, Warsaw.

[8] Two copies.
[9] Between the United States and England only.
[10] Changed from Hungarian Libraries Board.

PORTUGAL: Secção de Trocas Internacionais, Biblioteca Nacional, Lisbon.
QUEENSLAND: Bureau of Exchanges of International Publications, Chief Secretary's Office, Brisbane.
SOUTH AUSTRALIA: South Australian Government Exchanges Bureau, Government Printing and Stationery Office, Adelaide.
SPAIN: Junta de Intercambio y Adquisición de Libros y Revistas para Bibliotecas Públicas, Ministerio de Educación Nacional Avenida Calvo Sotelo 20, Madrid.
SWEDEN: Kungliga Biblioteket, Stockholm.
SWITZERLAND: Service Suisse des Échanges Internationaux, Bibliothèque Centrale Fédérale, Palais Fédéral, Berne.
TASMANIA: Secretary of the Premier, Hobart.
TURKEY: Ministry of Education, Department of Printing and Engraving, Istanbul.
UNION OF SOUTH AFRICA: Government Printing and Stationery Office, Cape Town, Cape of Good Hope.
UNION OF SOVIET SOCIALIST REPUBLICS: Bureau of Book Exchange, State Lenin Library, Moscow 19.
VICTORIA: Public Library of Victoria, Melbourne.
WESTERN AUSTRALIA: Public Library of Western Australia, Perth.
YUGOSLAVIA: Bibliografski Institut FNRJ, Belgrade.

Respectfully submitted.

D. G. WILLIAMS, *Chief.*

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the National Gallery of Art

SIR: I have the honor to submit, on behalf of the Board of Trustees, the seventeenth annual report of the National Gallery of Art, for the fiscal year ended June 30, 1954. This report is made pursuant to the provisions of section 5 (d) of Public Resolution No. 14, Seventy-fifth Congress, first session, approved March 24, 1937 (50 Stat. 51).

ORGANIZATION

The statutory members of the Board of Trustees of the National Gallery of Art are the Chief Justice of the United States, the Secretary of State, the Secretary of the Treasury, and the Secretary of the Smithsonian Institution, ex officio. The five general trustees continuing in office during the fiscal year ended June 30, 1954, were Samuel H. Kress, Ferdinand Lammot Belin, Duncan Phillips, Chester Dale, and Paul Mellon. The Board of Trustees held its annual meeting on May 4, 1954. Samuel H. Kress was reelected President and Ferdinand Lammot Belin Vice President, to serve for the ensuing year. Donald D. Shepard resigned on July 20, 1953, as Adviser to the Board. The Board of Trustees of the National Gallery of Art accepted Mr. Shepard's resignation at a meeting held on October 20, 1953.

Col. Harry A. McBride retired as Administrator of the Gallery on June 30, 1953, and Ernest R. Feidler was elected and appointed Administrator, effective July 1, 1953, to succeed Col. McBride. Mr. Feidler took office on January 1, 1954. The four other executive officers of the Gallery continued in office during the year. The executive officers of the Gallery as of June 30, 1954, are:

Huntington Cairns, Secretary-Treasurer.
David E. Finley, Director.
Ernest R. Feidler, Administrator.
Huntington Cairns, General Counsel.
John Walker, Chief Curator.
Macgill James, Assistant Director.

The three standing committees of the Board, as constituted at the annual meeting May 4, 1954, were as follows:

EXECUTIVE COMMITTEE

Chief Justice of the United States, Earl Warren, Chairman.
Samuel H. Kress, Vice Chairman.
Ferdinand Lammot Belin.
Secretary of the Smithsonian Institution, Dr. Leonard Carmichael.
Paul Mellon.

FINANCE COMMITTEE

Secretary of the Treasury, George M. Humphrey, Chairman.
Chester Dale, Vice Chairman.
Samuel H. Kress.
Ferdinand Lammot Belin.
Paul Mellon.

ACQUISITIONS COMMITTEE

Ferdinand Lammot Belin, Chairman.
Duncan Phillips.
Chester Dale.
Paul Mellon.
David E. Finley.

PERSONNEL

On June 30, 1954, full-time Government employees on the staff of the National Gallery of Art numbered 306, as compared with 302 employees as of June 30, 1953. The United States Civil Service regulations govern the appointment of employees paid from appropriated public funds.

APPROPRIATIONS

For the fiscal year ended June 30, 1954, the Congress of the United States appropriated for the National Gallery of Art $1,275,000 to be used for salaries and expenses in the operation and upkeep of the Gallery, the protection and care of works of art acquired by the Board of Trustees, and all administrative expenses incident thereto, as authorized by U. S. Code, title 20, sec. 74 (a), that is, section 4 (a) of the Public Resolution approved March 24, 1937 (50 Stat. 51). The following expenditures and encumbrances were incurred:

Personal services	$1,135,520.00
Printing and reproduction	5,693.04
Electricity, supplies, equipment, etc	133,260.25
Reserve	140.00
Unobligated balance	386.71
Total	1,275,000.00

ATTENDANCE

During the fiscal year 1954 there was a daily average of about 2,444 visitors to the Gallery. Since March 17, 1941, when the Gallery was opened to the public, to June 30, 1954, there have been 22,818,696 visitors.

ACCESSIONS

There were 1,010 accessions by the National Gallery of Art as gifts, loans, or deposits during the fiscal year. Most of the paintings and a number of the prints were placed on exhibition.

GIFTS

PAINTINGS

The Board of Trustees on July 1, 1953, accepted from Edgar William and Bernice Chrysler Garbisch 142 paintings from their collection of early American works of art. On October 20 the Board accepted the gift of a painting from Mr. and Mrs. Cornelius Vanderbilt Whitney entitled "The Biglen Brothers Racing" by Eakins. The gift of two paintings from Mrs. A. V. Tack entitled "Violet" and "Portrait of a Lady," both by George Fuller, was accepted by the Board on October 20. The Board, on December 2, ratified the acceptance of a gift from an anonymous donor of a portrait of James Forrestal by Albert K. Murray, which will be held for a National Portrait Gallery. The gift of a portrait of Andrew W. Mellon by Gari Melchers, offered by Donald D. Shepard, was accepted by the Board on December 2, 1953. On this same date the Board accepted a painting entitled "Coast of Naples" by William Haseltine, the gift of Mrs. Helen Plowden. The Board accepted from Lewis Einstein a "Portrait of a Young Woman" by Boucher, on December 28. The gift of a painting by George Luks entitled "The Miner" from Chester Dale was accepted by the Board on January 26, 1954. On the same date the Board accepted the following paintings from The A. W. Mellon Educational and Charitable Trust:

Artist	*Title*
Benbridge	James De Lancey.
Earl, Ralph	William Shepard.
Eichholz	Henry Leman.
Lambdin	Daniel Webster.
Morse	Levi Lincoln.
Pelham	John Cushing.
Courter	Lincoln and his Son, Tad.
Stuart	Lt. Robert Calder.
Stuart	William Constable.
Stuart	Sir John Dick.
Stuart	James Massy Dawson.

On May 4, the Board accepted the following paintings from Chester Dale: "The Artist's Garden" by Blakelock, "New York Street Scene in Winter" by Henri, "The Laundresses" by Steinlen, and "Moonlight" by Weir. At the same meeting, the Board accepted the gift of a portrait of Queen Victoria by Winterhalter from the children of the late William H. Donner. On the same date, the Board accepted from Mrs. A. V. Tack a Self-Portrait by her father, George Fuller. On May 19, the Board accepted from Miss Alice Preston a painting by Angelica Kauffman of the Countess Françoise Krazinska. The gift of a painting by Corot entitled "Italian Girl" was accepted from the Avalon Foundation by the Board of Trustees on June 10, 1954. In a letter received June 22, 1954, Mrs. Robert Homans gave the

Gallery two portraits by Stuart, "John Adams" and "Mrs. John Adams." The Board of Trustees had accepted this gift on May 6, 1952.

SCULPTURE

On October 20, 1953, the Board of Trustees accepted from Lessing J. Rosenwald two bronzes by Daumier, "Figure" and "Le Défenser Officier."

DECORATIVE ARTS

On December 28, 1953, the Board of Trustees accepted from Lewis Einstein the gift of a porphyry vase with base.

PRINTS AND DRAWINGS

On October 20 the Board of Trustees accepted 246 prints and drawings from Lessing J. Rosenwald to be added to his gift to the Gallery. In December, George Matthew Adams transferred to the Gallery 56 etchings by Alphonse Legros as his gift for 1953. His collection of prints by Legros was accepted by the Board on May 10, 1946.

OTHER GIFTS

Gifts of books on works of art and related material were made to the Gallery by Harold K. Hochschild and others. Gifts of money were made during the fiscal year 1954 by the Old Dominion Foundation and the Avalon Foundation.

EXCHANGE OF WORKS OF ART

On July 1, 1953, the Board approved Lessing J. Rosenwald's offer to exchange the engraving "Death of the Virgin" by Lucantonio degli Uberti for a superior impression of the same work.

WORKS OF ART ON LOAN

During the fiscal year 1954 the following works of art were received on loan by the National Gallery of Art:

From—	*Artist*
Chester Dale, New York, N. Y.:	
Landscape with Sail Boat	Beckwith.
Portrait of Beckwith	Carolus Duran.
Portrait of a Woman	Flemish, XVI Century.
Portrait of a Girl	German, XVI Century.
Portrait of a Woman	Pisanello, style of.
Still Life with Fish	Carlsen.
Mrs. Chase in Prospect Park	Chase.
Sweet Tremulous Leaves	A. B. Davies.
Flecks of Foam	Dearth.
Indian Maiden	Wright, Joseph.
The Seine at Giverny	Monet.
Early Scholar	Johnson, Eastman.
Arthur Sachs, Paris, France:	
The Bullfight	Goya, attributed to.

WORKS OF ART ON LOAN—Continued

From—	*Artist*
Edgar William and Bernice Chrysler Garbisch, New York, N. Y.:	
182 early American paintings.	
Robert Woods Bliss, Washington, D. C.:	
72 objects of Pre-Columbian art.	

LOANED WORKS OF ART RETURNED

The following works of art on loan were returned during the fiscal year 1954:

To—	*Artist*
Chester Dale, New York, N. Y.:	
Madame G	Sargent.
The Communicant	Carrière.
Basket	Dufy.
View of Fez	Dufy.
Marigolds and Tangerines	Vallotton.
Vendor of Ices	Gromaire.
Nude	De La Fresnaye.
Landscape with Sailboat	Beckwith.
Portrait of Beckwith	Carolus Duran.
Copley Amory, Washington, D. C:	
The Copley Family	Copley.
John Wiley, Washington, D. C.:	
Russian Icon.	
Paul Rosenberg & Co., New York, N. Y.:	
Madame Fantin-Latour	Degas.
Edgar William and Bernice Chrysler Garbisch, New York, N. Y.:	
John Hart	C. P. Polk.
Mrs. John Hart and Daughter	C. P. Polk.
Lucy Windsor	Hathaway.
John Cruger	Unknown.
Anna Cruger	Unknown.
Off to the Front	Unknown.
Cabinet Maker with Folding Rule	Unknown.
Little Girl in Pink with Rose	Unknown.
Young Man with Yellow Vest	Unknown.
Young Girl with Yellow Dress	Unknown.

WORKS OF ART LENT

During the fiscal year 1954 the Gallery lent the following works of art for exhibition purposes:

To—	*Artist*
Albright Art Gallery, Buffalo, N. Y.:	
Mrs. Richard Yates	Stuart.
Chicago Art Institute, Chicago, Ill.:	
White Girl	Whistler.
Mrs. Endicott	Sargent.
Blair-Lee House, Washington, D. C.:	
The Bersaglieri	Luks.

To—	*Artist*
U. S. Capitol, Architect's Office, Washington, D. C.:	
Daniel Webster	Lambdin.
Lincoln and his Son, Tad	Courter.
The White House, Washington, D. C.:	
The Windmill	Cazin.
The Rialto Bridge	Guardi.
Landscape with Boatman	Rousseau.
Los Angeles County Museum, Los Angeles, Calif.:	
Two-volume choir book known as the "Geesebook."	
De Young Memorial Museum, San Francisco, Calif.:	
Two-volume choir book known as the "Geesebook."	
University of Arizona, Tucson, Ariz.:	
Two-volume choir book known as the "Geesebook."	
Philbrook Art Center, Tulsa, Okla.:	
Two-volume choir book known as the "Geesebook."	
Metropolitan Museum of Art, New York, N. Y.:	
The White Girl	Whistler.
Mrs. Endicott	Sargent.
Montreal Museum, Montreal, Canada:	
Costume Study (drawing)	Dürer.
Ohio University, Athens, Ohio:	
Henry Pratt	Sully.
Smithsonian Institution, Washington, D. C. (For exhibition at the Cooper Union, New York, N. Y., and in Europe):	
La Toilette (print)	Cassatt.
Weary (print)	Whistler.
Smithsonian Institution, Washington, D. C. (For exhibition in Europe):	
The Steamer St. Lawrence	James Bard.
Portrait of a Boy	Waters, attributed to.
Mr. Bradley	Phillips.
Mrs. Bradley	Phillips.
Regatta near Sandy Hook	Unknown.
White Farm House	Unknown.
Harness Racing	Unknown.
Christ and Rebecca at the Well	Unknown.
John Stone	Unknown.
Eliza Welch Stone	Unknown.
Winter Scene in Maine	Unknown.
Sophia Mead	Unknown.

EXHIBITIONS

The following exhibitions were held at the National Gallery of Art during the fiscal year 1954:

French Paintings since 1870. From the Maurice Wertheim Collection. July 1 through September 13, 1953.

American Paintings from the Collection of the National Gallery of Art. July 22 through September 20, 1953.

Water Colors and Drawings by Gavarni. From the Walters Art Gallery and the Lessing J. Rosenwald Collections. October 4 through November 1, 1953.

Contemporary American Indian Painting. Organized in cooperation with Miss Dorothy Dunn, founder of the Department of Painting, U. S. Indian School, Santa Fe, N. Mex. November 8 through December 6, 1953.

Masterpieces of Graphic Art. From the Lessing J. Rosenwald Collection. December 20, 1953, to February 7, 1954, and from March 17 to April 25, 1954.

Masterpieces of Pre-Columbian Gold. From the Gold Museum of the Banco de la República, Bogotá. January 20 through February 18, 1954.

Drawings and Water Colors by Flemish and Dutch Masters. From the De Grez Collection and lent by the Musées Royaux des Beaux-Arts de Belgique. February 14 through March 14, 1954.

American Primitive Paintings. From the Collection of Edgar William and Bernice Chrysler Garbisch. Opened May 9, 1954.

TRAVELING EXHIBITIONS

Rosenwald Collection.—Special exhibitions of prints from the Rosenwald Collection were circulated to the following places during the fiscal year 1954:

Birmingham Museum of Art, Birmingham, Ala.:
Old Master Etchings and Engravings.
October 1953.

Smith College Museum of Art, Northampton, Mass.:
Renaissance Portraits.
October 1953.

Andrew Dickson White Museum of Art, Cornell University, Ithaca, N. Y.:
Masterpieces of Graphic Arts.
November 1953.

Cosmopolitan Club, Philadelphia, Pa.:
Scherzi from the Age of Reason.
November 13–December 4, 1953.

Los Angeles County Museum, Los Angeles, Calif.:
Medieval Manuscripts.
Nuremberg and the German World.
November–December 1953.

Lowe Gallery, University of Miami, Coral Gables, Fla.:
Masterpieces of Graphic Art.
November 1953.

Philadelphia Museum of Art, Philadelphia, Pa.:
Whistler Prints and Drawings.
November 1953.

Virginia Museum of Fine Arts, Richmond, Va.:
Daumier lithograph.
November 1953.

The Dayton Art Institute, Dayton, Ohio:
Flight, Fantasy, Faith, Fact.
December 1953–February 1954.

American University, Washington, D. C.:
German Expressionists—Prints and Drawings.
February 1954.

Howard University, Washington, D. C.:
Negro Subjects.
February 1954.
Pierpont Morgan Library, New York, N. Y.:
Blake engravings for the Füseli Exhibition.
February 1954.
Lowe Gallery, University of Miami, Coral Gables, Fla.:
Toulouse-Lautrec Exhibition.
March 1954.
Smithsonian Institution, Washington, D. C.:
Cassatt and Whistler Drawings.
Abroad from March through September 1954.
Columbia Museum of Art, Columbia, S. C.:
Toulouse-Lautrec Exhibition.
April 1954.
Telfair Academy of Arts and Sciences, Savannah, Ga.:
Toulouse-Lautrec Exhibition.
May 1954.
Tyler School of Art, Elkins Park, Pa.:
Prints for Hobby Show.
May 1954.

Index of American Design.—During the fiscal year 1954, 37 traveling exhibitions of original watercolor renderings of this collection, with 69 bookings, were sent to the following States and countries:

State or country	*Number of exhibitions*
Alabama	1
Arkansas	1
Colorado	12
Delaware	1
District of Columbia	5
Florida	1
Georgia	1
Illinois	3
Indiana	1
Iowa	8
Maryland	1
Massachusetts	3
Michigan	2
Nebraska	1
New Hampshire	1
New Jersey	3
New York	6
North Carolina	3
Ohio	1
Pennsylvania	5
South Carolina	1
Tennessee	1
Virginia	4
Wisconsin	1
Western Germany	1
Palestine	1

CURATORIAL ACTIVITIES

The Curatorial Department accessioned 476 gifts to the Gallery during the fiscal year 1954. Advice was given regarding 290 works of art brought to the Gallery for expert opinion, and 38 visits to other collections were made by members of the staff for either expert opinion or in connection with offers of gifts. About 1,500 inquiries requiring research were answered verbally and by letter. John Walker gave an address at the Philbrook Art Center, Tulsa, on the occasion of the opening of the Samuel H. Kress Collection in that museum. Mr. Walker also gave a talk on the X-raying of paintings during the intermission period of the regular Sunday evening concert broadcast at the Gallery. A recording was made of an interview with Mr. Walker and a member of the staff of the Columbia Broadcasting System regarding the Edgar William and Bernice Chrysler Garbisch Collection and this interview was broadcast nationally. Perry B. Cott gave a lecture on Renaissance Portrait Medals at Smith College. Charles M. Richards conducted two courses in art history under the auspices of the Department of Agriculture. He also gave lectures to six different local groups on "Bruegel," "Van Eyck," and the subjects "Taste" and "Contemporary Art." Miss Elizabeth Mongan assisted with seminar courses for Beaver College and Swarthmore College. She gave a lecture on medieval manuscripts and one on "Scherzi from the 18th Century" to two clubs. She also served on a panel discussion of modern art at the Springside School. Perry B. Cott and William P. Campbell were judges of an art exhibition at St. John's Church, Glyndon, Md.

Erwin O. Christensen, as a representative of the Gallery, attended the annual meeting of the American Association of Museums at Santa Barbara, Calif., in the spring. Miss Katharine Shepard, as secretary of the Washington Society, Archaeological Institute of America, was a delegate to the general meeting of the Institute in New York. At the invitation of the Cultural Division of the Bonn Government, Mr. Richards went to Germany in February for six weeks. He also visited museums, private collections, and universities and discussed problems of exhibition and installation with the personnel of the various institutions.

Mr. Richards mounted an exhibition at Arden House in connection with Columbia University's 200th Anniversary. Mr. Campbell selected and supervised the installation of some 850 reproductions of Gallery paintings in the new domiciliary building of the U. S. Soldiers' Home, Washington, D. C.

Special installations were prepared for the exhibition of Pre-Columbian gold, from the Museum of the Bank of Bogotá, under the direction of Mr. Cott. He also supervised the installation of new vitrines for the Robert Woods Bliss Collection of Pre-Columbian art.

Mr. Walker served as trustee for the American Federation of Arts and the American Academy in Rome. He also served on the following committees: Dumbarton Oaks Visiting Committee and the Art Committee of the New York Hospital. He was also a member of the United States National Commission for UNESCO. Mr. Cott served on the Fine Arts Committee of the Washington Cathedral and the Interdepartmental Committee for the Protection of Cultural Property (UNESCO). He was elected president of the Washington Society, Archaeological Institute of America.

RESTORATION AND REPAIR OF WORKS OF ART

Necessary restoration and repair of paintings and sculpture in the Gallery's collection were made by Francis Sullivan, resident restorer to the Gallery.

PUBLICATIONS

John Walker wrote a series of articles on paintings in the Chester Dale Collection which appeared in the Ladies Home Journal.

Miss Mongan wrote an article on modern prints for the College Art Journal.

Mr. Campbell prepared the text of the sixth edition of the catalog, French Paintings from the Chester Dale Collection. He also composed the catalog American Primitive Paintings from the Collection of Edgar William and Bernice Chrysler Garbisch.

Mrs. Shapley continued the preparation of a new catalog of paintings.

A monograph on Giovanni Bellini's "Feast of the Gods" is being revised by Mr. Walker.

During the fiscal year 1954 the Publications Fund added 12 new 11- by 14-inch color reproductions to the list available. Twenty-eight new monotone postcards and five new Christmas-card color plates were also added. Eight large collotype reproductions of paintings in the permanent collection as well as six reproductions of paintings from the twentieth-century French paintings in the Chester Dale loan collection, distributed by a New York publisher, were placed on sale.

At the Christmas season a new Portfolio No. 3, entitled "Portraits of Children in the National Gallery of Art," was published. In the spring of 1954 a catalog of "American Primitive Paintings from the Collection of Edgar William and Bernice Chrysler Garbisch" was issued. The Mellon and original Dale catalogs, the latter in a somewhat enlarged edition, were reprinted during the year.

Exhibition catalogs of the Flemish and Dutch Drawings and Watercolors, Gavarni, Pre-Columbian Gold, and Contemporary American Indian Painting shows were also made available to the public.

EDUCATIONAL PROGRAM

The attendance for the general, congressional, and special tours and the "Picture of the Week" totaled 41,906, while the attendance at 38 auditorium lectures on Sunday afternoons was approximately 10,600 during the fiscal year 1954.

Tours, lectures, and conferences arranged by appointment were given to 146 groups and individuals. The total number of people served in this manner was 3,456. These special appointments were made for such groups as representatives from leading universities and museums, other governmental departments, high schools, colleges, women's clubs, and a number of foreign visitors. This service also included two training programs, one for the Washington Junior League volunteers who thereafter conducted tours for art students in the Washington high schools, and the other for members of the Arlington branch of the American Association of University Women who conducted tours in the Gallery for all the Arlington public-school children in grades 2 to 6.

The staff of the Educational Office delivered 13 lectures in the auditorium on Sunday afternoons, while 25 were given by guest speakers. During April and May Sir Herbert Read delivered the Third Annual Series of the six A. W. Mellon Lectures in the Fine Arts on the theme "The Art of Sculpture."

During the past year 200 persons borrowed 5,457 slides from the lending collection, and 16 copies of the National Gallery of Art film have been placed in distribution centers throughout the country. Arrangements were made with each center to serve certain States so that every State in the Union has a copy of the film available nearby. The slide lecture "The Christmas Story in Art" was popular again, having been shown to approximately 5,894 people. Members of the Educational Office prepared and gave 28 broadcasts to accompany the Sunday night concerts over Station WGMS.

The printed Calendar of Events announcing all Gallery activities and publications is distributed monthly to a mailing list of more than 4,000 names.

LIBRARY

The most important contributions to the Library during the fiscal year 1954 were 8,767 books, pamphlets, periodicals, subscriptions, and photographs purchased from funds made available for this purpose. Gifts included 479 books, pamphlets, and periodicals, while 812 books, pamphlets, and bulletins were received from other institutions.

Although the Library is not open to the public it is possible for students of art and persons with art questions to use the services of the Library. During this fiscal year the Library staff handled 630

reference questions and served 350 readers other than the Gallery staff.

The Library is the depository for photographs of the works of art in the collections of the National Gallery of Art, and is the base for circulation activity, maintaining a stock of reproductions for the specific purposes of research, exchange, publicity, and sale. During the year approximately 500 individuals other than members of the Gallery staff purchased prints from the Library and about 250 mail orders were filled.

INDEX OF AMERICAN DESIGN

During the fiscal year 1954, there were 37 traveling exhibitions of original watercolor renderings of this collection with 69 bookings, representing an increase over last year. The Index material was used during the year by 440 persons doing special research, seeking material for publication, exhibitions, slides, and for use by designers.

A total of 533 photographs of Index material were sent out of the Gallery on loan, for publicity, and purchase. Thirty sets (consisting of 1,310 slides) of 2- by 2-inch slides circulated in 16 States and in Italy.

MAINTENANCE OF THE BUILDING AND GROUNDS

The usual work in connection with the care of the building and its mechanical equipment and the grounds was maintained throughout the year.

The stonemason opened the joints and repointed the marble floors in the garden courts and the Fourth Street lobby where spalling of the marble was occurring owing to the rising of the phantasia marble borders. It is the opinion of marble experts that this should prevent further damage to the floors in these areas.

Flowering and foliage plants were grown in the moats and used in the garden courts; and a new overhead sprinkler system was installed in the northwest moat, thereby reducing labor costs in maintaining these plants.

One of the two white pines near the building at the west fountain died; therefore it and its companion tree opposite were removed and replaced by two *Magnolia grandiflora*, thus balancing the magnolia planting at the east fountain, where the pines died and were replaced a number of years ago. The dead boxwoods at the Fourth Street entrance were replaced by specimen *Taxus* (*cuspidata*), and plants were replaced in the *Taxus* hedges as necessary.

A contract was entered into with Lord and Burnham on May 17, 1954, for supplying materials for a greenhouse in the southwest moat. Upon receipt of the materials the greenhouse will be erected by the Gallery staff.

OTHER ACTIVITIES

Thirty-seven Sunday evening concerts were given during the fiscal year 1954 in the West Garden Court. The National Gallery Orchestra, conducted by Richard Bales, played eight concerts at the Gallery with additional performances at the United States Naval Academy at Annapolis, Md., and at the Community Center in Middleburg, Va. One of the orchestral concerts at the National Gallery was made possible by the Music Performance Trust Fund of the American Federation of Musicians. During April and May, five Sunday evenings were devoted to the Gallery's Eleventh American Music Festival. All the concerts were broadcast in their entirety by Station WGMS, Washington, D. C., and the Good Music Network. The intermissions, during these broadcasts, featured discussions by members of the curatorial staff on major aspects of the National Gallery as well as on musical subjects by Mr. Bales.

During September 1953, the National Gallery Orchestra assisted by the Church of the Reformation cantata choir and soloists recorded for Columbia Masterworks the long-playing record of "The Confederacy" by Mr. Bales. This record is scheduled for release during the fall of 1954.

The photographic laboratory of the Gallery produced 12,180 prints, 386 black-and-white slides, 708 color slides and 101 color transparencies, in addition to 2,106 negatives, infrared and ultraviolet photographs.

During the fiscal year, 1,682 press releases were issued in connection with Gallery activities, and 202 permits to copy paintings and 184 permits to photograph in the Gallery were issued.

AUDIT OF PRIVATE FUNDS OF THE GALLERY

An audit of the private funds of the Gallery has been made for the fiscal year ended June 30, 1954, by Price Waterhouse & Co., public accountants, and the certificate of that company on its examination of the accounting records maintained for such funds will be forwarded to the Gallery.

Respectfully submitted.

HUNTINGTON CAIRNS, *Secretary.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on the Library

SIR: I have the honor to submit the following report on the activities of the Smithsonian Library for the fiscal year ended June 30, 1954:

The receipt of a grand total of 69,484 publications was recorded in the receiving room of the library during the past year. The largest number of them came, as usual, from the scientific, technical, educational and other cultural institutions all over the world with which the Smithsonian Institution has exchange relations.

In all, 515 new exchanges were arranged for the library, and 6,527 publications, chiefly numbers of periodicals needed to fill gaps in the collections, were obtained either in exchange or as gifts, by making special requests for them. Purchases included 578 books and subscriptions for 436 indispensable periodicals not obtainable by exchange.

The recorded number of gifts of books, periodicals, and pamphlets received from many different generous friends of the Institution was 21,604. To this number will be added the recent gift from Gerrit S. Miller, Jr., of several hundred publications on zoology, not yet counted by items. Mr. Miller had kept this personal collection in the Museum while he was curator of mammals, and when he retired, some years ago, he very kindly left it in the division of mammals for the use of the staff. His generosity in giving formal assurance to the Institution of the continued use of these books and papers is most gratifying. An especially important part of the gift is a set of 13 bound volumes of Mr. Miller's own collected writings.

The library added 5,836 publications to the Smithsonian Deposit in the Library of Congress, most of them parts of foreign serial publications. Other publications sent to the Library of Congress included 6,409 foreign and state documents, 1,803 doctoral dissertations chiefly from European universities, and 14,231 miscellaneous publications of other sorts.

Incoming publications known to be in the immediate fields of the special interests of other agencies of the Government, such as medical dissertations and publications on agricultural economics, were sent to the libraries of the agencies, and 4,924 were so transferred, principally to the Armed Forces Medical Library and to the Department of Agriculture Library.

There was little opportunity to work on the duplicate collection, but it was profitably reduced by the selection of 71,063 pieces, which were

sent for credit to the United States Book Exchange in the Library of Congress. Incoming publications found to be unneeded duplicates were disposed of as promptly and as usefully as possible.

By agreement with the Library of Congress, some hundreds of publications, forming part of the Langley Aeronautical Library that had been sent as part of the Smithsonian Deposit to the Library of Congress in 1930 and later, were returned to the Institution for incorporation in the library of the National Air Museum.

Records of the catalog section show that 4,234 books were cataloged and that 22,473 periodicals were entered. There were 31,156 new catalog cards filed. A good deal of further progress was made in the work of combining into a single comprehensive dictionary catalog the formerly separately maintained Smithsonian union catalog and the Museum catalog. More than 172,000 cards were handled in the process of revising, reconciling discrepancies, and integrating the records. It is hoped that this important work may be finished during the coming year.

There is no arrearage in the cataloging of the routine inflow of current acquisitions, but the arrearage in the cataloging of special collections mounts with each such acquisition. Not increasing, but also not being reduced, is the arrearage of cataloging of many hundreds of other volumes in bureau and sectional libraries throughout the institution, which badly needs to be done. In all, there are estimated to be about 153,000 volumes that are either not represented in the main library catalog at all, or of which the records, made many years ago, are now so obsolete as to make their exact identification and present location uncertain. The library staff must have more help before these conditions can be rectified.

Circulation records show that 11,654 publications were borrowed for use outside the library. This figure does not include 6,219 new books and current numbers of periodicals assigned to sectional libraries for circulation and filing.

So large a part of the library's collections are decentralized among unstaffed bureau and sectional libraries, housed in many different parts of four separate buildings, that no statistical records can be kept of the very intensive use made of these thousands of books on highly specialized subjects. There is direct access to the stacks in the main library, too, and readers make large use of this privilege, but no count of the number of persons entering the stacks or of how many books they consult there is attempted.

That the services of the library are by no means limited to the

staff of the Institution is well attested by the many research workers from other agencies of the Government and by visiting scientists and other scholars, from abroad as well as from institutions in this country, who make reference use of the library's resources.

By interlibrary loans, too, the library's resources are further extended, and 1,431 publications were borrowed by 90 different libraries during the year. The library, in turn, borrowed 1,482 publications from the Library of Congress—many of them Smithsonian Deposit copies—and 441 from other libraries, chiefly from the Department of Agriculture, the Geological Survey, and the Armed Forces Medical Library.

More than 15,000 reference questions were answered in the reference and circulation section. The chief of the section cooperated with the Library of Congress in making a comparative check and relisting of the semipermanent loan records of Smithsonian Deposit and other publications borrowed from the Library of Congress for continued use by the Institution. These records covered many years, discrepancies in them were numerous, and the revision and corrected listing of the many different items was an important piece of work.

Funds permitted the binding of 1,917 volumes for the library. A large binding backlog still exists.

Most welcome relief to the very severe overcrowding of the shelves in the main library in the Natural History Building was afforded by the erection of a deck in room 28, and the installation of steel stacks providing shelf room for about 17,000 volumes. This made it possible to do away with the double shelving, use of tops of cases, window sills, and other makeshift means of keeping the overflow of the shelves off the floor. The improved appearance of the library is conspicuous. Overcrowding in other units of the library was not affected, and the over-all housing problem continues to be serious. The National Collection of Fine Arts library, especially, is acutely in need of relief.

Understaffing continued to keep the bureau libraries closed to all but staff members of the bureaus, except by special arrangement. The Bureau of American Ethnology was perhaps the greatest sufferer from lack of full-time reference and custodial library service, for its collections on the Indians of North America are unique in many respects, and they are much depended upon by other agencies of the Government, as well as by independent scholars, for authoritative information on many matters, sometimes involving very important legal decisions.

SUMMARIZED STATISTICS

ACCESSIONS

	Volumes	Total recorded volumes, 1954
Smithsonian Deposit at the Library of Congress	295	584, 590
Smithsonian main library (includes former Office and Museum branches)	3, 470	293, 257
Astrophysical Observatory (includes Radiation and Organisms)	119	14, 221
Bureau of American Ethnology	162	35, 512
National Air Museum	17	323
National Collection of Fine Arts	171	13, 455
National Zoological Park		4, 204
Total	4, 234	945, 562

Cataloged volumes only have been counted in these records of current accessions and no incomplete volumes of serial publications or separates and reprints from serial publications, of which there are many thousands, are included in any of the totals.

EXCHANGES

New exchanges arranged 515
192 of these were for the Smithsonian Deposit.
Specially requested publications received 6, 527
1,031 of these were obtained to fill gaps in Smithsonian Deposits sets.

CATALOGING

Volumes cataloged 4, 234
Catalog cards filed 31, 156

PERIODICALS

Periodical parts entered 22, 473
5,541 were sent to the Smithsonian Deposit.

CIRCULATION

Loans of books and periodicals 11, 654
Circulation of books and periodicals in sectional libraries is not counted, except in the Division of Insects.

BINDING

Volumes sent to the bindery 1, 917
Volumes repaired in the library 613

Respectfully submitted.

LEILA F. CLARK, *Librarian.*

Dr. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report on Publications

SIR: I have the honor to submit the following report on the publications of the Smithsonian Institution and its branches for the year ended June 30, 1954:

The publications of the Smithsonian Institution, comprising eight regular series and six others appearing from time to time, are issued partly from federally appropriated funds (Smithsonian Reports, publications of the National Museum and the Bureau of American Ethnology) and partly from private endowment funds (Smithsonian Miscellaneous Collections, publications of the Freer Gallery of Art, and some special publications). This past year there has been added the series known as Ars Orientalis, which will be edited by the Smithsonian Institution under the auspices of the Freer Gallery and will appear under the imprint of the University of Michigan and the Smithsonian Institution. The first number of this series was in press at the close of the year. The Institution also publishes a guide book, postcards, photo albums, color slides, and picture books for sale to visitors. Through its publication program the Smithsonian endeavors to carry out its founder's expressed desire for the diffusion of knowledge.

During the year the Institution published 14 papers in the Smithsonian Miscellaneous Collections, 1 Annual Report of the Board of Regents and pamphlet copies of 17 articles in the Report appendix, 1 Annual Report of the Secretary, and 1 special publication.

The United States National Museum issued 1 Annual Report of the Director, 13 Proceedings papers, 1 Bulletin, and 2 papers in the series Contributions from the United States National Herbarium.

The Bureau of American Ethnology issued 1 Annual Report and 3 Bulletins.

The National Collection of Fine Arts issued 1 catalog, and the Traveling Exhibition Service published catalogs for 3 of the circulating exhibits.

There were distributed 468,600 pieces of printed matter—141,953 copies of the publications and 326,647 miscellaneous items. Publications: 54 Contributions to Knowledge, 31,243 Smithsonian Miscellaneous Collections, 10,527 Annual Report volumes and 15,811 Report separates, 1,367 War Background Studies, 3,920 special publications, 27 reports and 105 pictures of the Harriman Alaska Expedition; 44,095 publications of the National Museum, 21,229 Bureau of American Ethnology publications, 7,589 National Collection of Fine Arts cata-

logs, 11 Freer Gallery of Art publications, 5 Annals of the Astrophysical Observatory, 5,912 Reports of the American Historical Association, and 58 publications not published by the Smithsonian Institution. Miscellaneous: 18 sets and 38 prints of North American Wild Flowers, and 5 Pitcher Plant volumes; 83,761 Guide Books; 223,173 postcards; 4,218 photo packets; and 15,434 picture pamphlets.

The 1954 allotment from Government funds of $92,320 for printing and binding was entirely obligated at the close of the year.

SMITHSONIAN PUBLICATIONS

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 120

Smithsonian Physical Tables. Ninth Revised edition. Prepared by William Elmer Forsythe. 827 pp., 36 figs. (Publ. 4169.) [June] 1954. (Cloth-bound, $10.00; paper-bound, $9.00.)

VOLUME 121

No. 12. The Pleistocene fauna of Wailes Bluff and Langleys Bluff, Maryland, by S. F Blake. 32 pp., 1 pl., 1 fig. (Publ. 4129.) Aug. 11, 1953. (40 cents.)

VOLUME 122

No. 2. New and inadequately known North American species of the copepod genus *Diaptomus*, by Mildred Stratton Wilson. 30 pp., 58 figs. (Publ. 4132.) Aug. 4, 1953. (35 cents.)

No. 4. Solar variation, a leading weather element, by C. G. Abbot. 35 pp., 22 figs. (Publ. 4135.) Aug. 4, 1953. (40 cents.)

No. 5. Silver-disk pyrheliometry, by W. H. Hoover and A. G. Froiland. 10 pp., 1 pl., 2 figs. (Publ. 4136.) Aug. 4, 1953. (20 cents.)

No. 6. The external morphology of the dragonfly *Onychogomphus ardens* Needham, by Hsiu-fu Chao. 56 pp., 50 figs. (Publ. 4137.) Sept. 15, 1953. (60 cents.)

No. 7. The geology of Chaco Canyon, New Mexico, in relation to the life and remains of the prehistoric peoples of Pueblo Bonito, by Kirk Bryan. 65 pp., 11 pls., 3 figs. (Publ. 4140.) Feb. 2, 1954. (90 cents.)

No. 8. Further additions to the birds of Panamá and Colombia, by Alexander Wetmore. 12 pp. (Publ. 4142.) Dec. 17, 1953. (15 cents.)

No. 9. Insect metamorphosis, by R. E. Snodgrass. 124 pp., 17 figs. (Publ. 4144.) Apr. 1, 1954. ($1.20.)

No. 10. Two silicified carboniferous trilobites from West Texas, by Harry S. Whittington. 16 pp., 3 pls., 1 fig. (Publ. 4146.) Apr. 22, 1954. (35 cents.)

No. 11. A revision of the sea-stars of the genus *Tethyaster*, by Ailsa M. Clark and Austin H. Clark. 27 pp., 12 pls., 2 figs. (Publ. 4147.) Apr. 8, 1954. (45 cents.)

No. 12. The reproduction of cockroaches, by Louis M. Roth and Edwin R. Willis. 49 pp., 12 pls. (Publ. 4148.) June 9, 1954. (80 cents.)

No. 13. Washington, D. C., precipitation for 1953 and 1954, by C. G. Abbot. 4 pp., 1 fig. (Publ. 4170.) Apr. 20, 1954. (10 cents.)

VOLUME 123

No. 1. Songs and stories of the Ch'uan Miao, by David C. Graham. 336 pp., 24 pls., 1 fig. (Publ. 4139.) Apr. 8, 1954. ($4.00.)

ANNUAL REPORTS

Report for 1952.—The complete volume of the Annual Report of the Board of Regents for 1952 was received from the printer September 24, 1953:

Annual Report of the Board of Regents of the Smithsonian Institution showing the operations, expenditures, and condition of the Institution for the year ended June 30, 1952. 461 pp., 43, pls., 24 figs. (Publ. 4111.)

The general appendix contained the following papers (Publs. 4112–4128):

Radio astronomy, by J. A. Ratcliffe.
The sun, the moon, and the tides, by Leo Otis Colbert.
Engineering and pure science, by W. F. G. Swann.
Man's synthetic future, by Roger Adams.
Phosphorus and life, by D. P. Hopkins.
The ice age in the North American Arctic, by Richard Foster Flint.
The 1944 eruption of Usu, in Hokkaido, Japan, by Takeshi Minakami, Toshio Ishikawa, and Kenzo Yagi.
Snails and their relations to the soil, by Harley J. Van Cleave.
The ecology, evolution, and distribution of the vertebrates, by Austin H. Clark.
Grasshopper Glacier of Montana and its relation to long-distance flights of grasshoppers, by Ashley B. Gurney.
Recent advances in the study and techniques of anatomy, by Paul G. Roofe and Samuel W. Lesher.
Livestock parasitology in the United States, by Benjamin Schwartz.
Botanizing with the Okinawans, by Egbert H. Walker.
Bromeliad malaria, by Lyman B. Smith.
Pharmacology of antibiotics, by Henry Welch.
An anthropologist looks at Lincoln, by T. D. Stewart.
The use of music in the treatment of the sick by American Indians, by Frances Densmore.

Report for 1953.—The Report of the Secretary, which will form part of the Annual Report of the Board of Regents to Congress, was issued January 15, 1954:

Report of the Secretary of the Smithsonian Institution and financial report of the Executive Committee of the Board of Regents for the year ended June 30, 1953. 165 pp., 7 pls. (Publ. 4141.) 1954.

SPECIAL PUBLICATIONS

The Smithsonian Institution. 32 pp., 15 pls. (Publ. 4145.) 1954.

PUBLICATIONS OF THE UNITED STATES NATIONAL MUSEUM

The National Museum issued 1 Annual Report of the Director, 13 Proceedings papers, 1 Bulletin, and 2 papers in the series Contributions from the United States National Herbarium, as follows:

ANNUAL REPORT

The United States National Museum annual report for the year ended June 30, 1953. vii+97 pp. [January 12, 1954.]

PROCEEDINGS

VOLUME 100

Title page, table of contents, list of illustrations, and index. Pp. i–viii, 553–584. Mar. 23, 1954.

VOLUME 101

Title page, table of contents, list of illustrations, and index. Pp. i–ix, 611–639. Mar. 23, 1954.

VOLUME 103

No. 3323. Review of the Indo-Pacific anemone fishes, genus *Amphiprion*, with descriptions of two new species, by Leonard P. Schultz. Pp. 187–201, pls. 9, 10. July 3, 1953.

No. 3324. Marine polychaete worms from Point Barrow, Alaska, with additional records from the North Atlantic and North Pacific, by Marian H. Pettibone. Pp. 203–356, figs. 26–39. May 21, 1954.

No. 3325. The relationships of Old and New World melanians, by J. P. E. Morrison. Pp. 357–394, pl. 11. Apr. 20, 1954.

No. 3326. Preliminary analysis of the fossil vertebrates of the Canyon Ferry Reservoir area, by Theodore E. White. Pp. 395–438, figs. 40–51. May 28, 1954.

No. 3327. A review of the labrid fish genus *Wetmorella* with descriptions of new forms from the tropical Indo-Pacific, by Leonard P. Schultz and N. B. Marshall Pp. 439–447, figs. 52–54, pl. 12. Apr. 21, 1954.

No. 3328. Review of the Atlantic periwinkles, *Nodilittorina*, *Echininus*, and *Tectarius*, by R. Tucker Abbott. Pp. 449–464, figs. 55–57. Mar. 23, 1954.

No. 3329. Mammals of northern Colombia, preliminary report No. 7; Tapirs (genus *Tapirus*), with a systematic review of American species, by Philip Hershkovitz. Pp. 465–496, figs. 58–62. May 18, 1954.

No. 3330. A revision of the goatfish genus *Upeneus* with descriptions of two new species, by Ernest A. Lachner. Pp. 497–532, pls. 13, 14. May 18, 1954.

No. 3331. Studies in neotropical Mallophaga, XI: Bird lice of the suborder Amblycera, genus *Dennyus* Neumann, by M. A. Carriker, Jr. Pp. 533–549, figs. 63, 64. May 21, 1954.

No. 3332. Nearctic flies of the family Periscelidae (Diptera) and certain Anthomyzidae referred to the family, by A. H. Sturtevant. Pp. 551–562. June 16, 1954.

No. 3333. North American triclad Turbellaria, XIII: Three new cave planarians, by Libbie Hyman. Pp. 563–573, figs. 65–68. June 14, 1954.

BULLETINS

202. Fishes of the Marshall and Marianas Islands, by Leonard P. Schultz and collaborators. xxxii+685 pp., 74 pls., 90 figs. Dec. 15, 1953.

CONTRIBUTIONS FROM THE UNITED STATES NATIONAL HERBARIUM

VOLUME 29

Part 11. Studies in the Bromeliaceae, XVII, by Lyman B. Smith. Pp. i–vi+ 521–543, figs. 77–94. Feb. 19, 1954.

VOLUME 81

Part 2. The Acanthaceae of Colombia, II, by Emery C. Leonard. i–viii+119–322 pp., figs. 41–118. Nov. 10, 1953.

PUBLICATIONS OF THE BUREAU OF AMERICAN ETHNOLOGY

During the year the Bureau issued 1 Annual Report and 3 Bulletins, as follows:

ANNUAL REPORT

Seventieth Annual Report of the Bureau of American Ethnology, 1952–1953. ii+33 pp. 1954.

BULLETINS

152. Index to Schoolcraft's "Indian Tribes of the United States," compiled by Frances S. Nichols. vi+257 pp. 1954.

154. River Basin Surveys Papers: Inter-Agency Archeological Salvage Program. Nos. 1–6. xviii+336 pp., 56 pls., 40 figs. 1953.

No. 1. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri River Basin Archeological Survey in 1948, by Waldo R. Wedel.

No. 2. Prehistory and the Missouri Valley Development Program: Summary report on the Missouri River Basin Archeological Survey in 1949, by Waldo R. Wedel.

No. 3. The Woodruff Ossuary, a prehistoric burial site in Phillips County, Kansas, by Marvin F. Kivett.

No. 4. The Addicks Dam sites:

I. An archeological survey of the Addicks Dam Basin, Southeast Texas, by Joe Ben Wheat.

II. Indian skeletal remains from the Doering and Kobs sites, Addicks Reservoir, Texas, by Marshall T. Newman.

No. 5. The Hodges site:

I. Two rock shelters near Tucumcari, New Mexico, by Herbert W. Dick.

II. Geology of the Hodges site, Quay County, New Mexico, by Sheldon Judson.

No. 6. The Rembert Mounds, Elbert County, Georgia, by Joseph R. Caldwell.

Appendix. List of River Basin Surveys reports published in other series.

156. The Iroquois Eagle Dance, an offshoot of the Calumet Dance, by William N. Fenton, with an analysis of the Iroquois Eagle Dance and songs, by Gertrude Prokosch Kurath. vi+324 pp., 28 pls., 36 figs. 1953.

PUBLICATIONS OF THE NATIONAL COLLECTION OF FINE ARTS

Catalog of American and European paintings in the Gellatly Collection. (Fourth Edition.) 19 pp., 14 pls. (Publ. 4143.) 1954. [January 1954.] (35 cents.)

Watercolors and drawings by Gavarni. (Smithsonian Institution Traveling Exhibition Service catalog.) [September 1953.]

Fuseli drawings. (Smithsonian Institution Traveling Exhibition Service catalog.) [January 1954.]

Carl Bodmer paints the Indian frontier. (Smithsonian Institution Traveling Exhibition Service catalog.) [February 1954.]

REPORT OF THE AMERICAN HISTORICAL ASSOCIATION

The annual reports of the American Historical Association are transmitted by the Association to the Secretary of the Smithsonian Institution and are by him communicated to Congress, as provided by the act of incorporation of the Association. The following report volumes were issued during the year:

Annual Report of the American Historical Association for the year 1951. Volume 2. Writings on American History, 1949.

Annual Report of the American Historical Association for the year 1952. Volume 1. Proceedings.

REPORT OF THE NATIONAL SOCIETY, DAUGHTERS OF THE AMERICAN REVOLUTION

The manuscript of the Fifty-sixth Annual Report of the National Society, Daughters of the American Revolution, was transmitted to Congress, in accordance with law, on March 17, 1954.

ORGANIZATION

Lester E. Commerford, chief of the division of publications, retired at the end of December after 48 years of service with the Institution, all in the division of publications.

Effective April 8, 1954, the editorial division and the publications division were combined under a new designation, the editorial and publications division. All the Institution's editorial, publication distribution and sales, and duplicating functions are now centralized under the direction of Paul H. Oehser, chief of the division, who also serves as public relations officer; John S. Lea, assistant chief of the division. Mrs. Eileen M. McCarthy is in charge of publication distribution; William D. Crockett, illustrations and layouts; and Alphonso Jones, duplicating. The Smithsonian's printing section (a branch of the Government Printing Office) continues under this division.

Respectfully submitted.

PAUL H. OEHSER,
Chief, Editorial and Publications Division.

DR. LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

Report of the Executive Committee of the Board of Regents of the Smithsonian Institution

For the Year Ended June 30, 1954

To the Board of Regents of the Smithsonian Institution:

Your executive committee respectfully submits the following report in relation to the funds of the Smithsonian Institution, together with a statement of the appropriations by Congress for the Government bureaus in the administrative charge of the Institution:

SMITHSONIAN ENDOWMENT FUND

The original bequest of James Smithson was £104,960 8s. 6d.—$508,318.46. Refunds of money expended in prosecution of the claim, freights, insurance, and other incidental expenses, together with payment into the fund of the sum of £5,015, which had been withheld during the lifetime of Madame de la Batut, brought the fund to the amount of $550,000.

Since the original bequest, the Institution has received gifts from various sources, the income from which may be used for the general work of the Institution. These, including the original bequest, plus savings, are listed below, together with the income for the present year.

ENDOWMENT FUNDS

(Income for the unrestricted use of the Institution)

Partly deposited in the United States Treasury at 6 percent and partly invested in stocks, bonds, and other holdings

Fund	Investment	Income present year
Parent Fund (original Smithson bequest, plus accumulated savings)	$729,001.82	$43,725.93
Subsequent bequests, gifts, and other funds, partly deposited in the U. S. Treasury and partly invested in the consolidated fund:		
Abbott, W. L., special fund	9,908.29	379.83
Avery, Robert S., and Lydia, bequest fund	58,062.83	3,025.35
Endowment fund	394,273.93	19,554.56
Habel, Dr. S., bequest fund	500.00	30.00
Hachenberg, George P. and Caroline, bequest fund	4,486.41	222.49
Hamilton, James, bequest fund	2,950.32	172.32
Henry, Caroline, bequest fund	1,349.15	66 87
Hodgkins, Thomas G. (general gift)	149,792.24	8,635.97
Porter, Henry Kirke, memorial fund	319,482.17	15,845.16
Rhees, William Jones, bequest fund	1,117.74	61.56
Sanford, George H., memorial fund	2,093.04	115.25
Witherspoon, Thomas A., memorial fund	143,960.04	7,139.88
Total	1,087,976.16	55,249 24
Grand total	1,816,977.98	98,975.17

The Institution holds also a number of endowment gifts, the income of each being restricted to specific use. These, plus accretions to date, are listed below, together with income for the present year.

Fund	Investment	Income present year
Abbott, William L., fund, for investigations in biology	$116,735.16	$5,768.38
Arthur, James, fund, for investigations and study of the sun and annual lecture on same	44,614.04	2,212.67
Bacon, Virginia Purdy, fund, for traveling scholarship to investigate fauna of countries other than the United States	55,889.26	2,771.89
Baird, Lucy H., fund, for creating a memorial to Secretary Baird	26,858.54	1,332.04
Barney, Alice Pike, memorial fund, for collection of paintings and pastels and for encouragement of American artistic endeavor	31,995.41	1,421.51
Barstow, Frederick D., fund, for purchase of animals for Zoological Park	1,115.30	55.31
Canfield Collection fund, for increase and care of the Canfield collection of minerals	42,665.99	2,116.04
Casey, Thomas L., fund, for maintenance of the Casey collection and promotion of researches relating to Coleoptera	13,982.62	693.47
Chamberlain, Francis Lea, fund, for increase and promotion of Isaac Lea collection of gems and mollusks	31,414.07	1,557.97
Dykes, Charles, bequest fund, for support in financial research	48,033.83	2,381.97
Eickemeyer, Florence Brevoort, fund, for preservation and exhibition of the photographic collection of Rudolph Eickemeyer, Jr	12,125.61	601.35
Hillyer, Virgil, fund, for increase and care of Virgil Hillyer collection of lighting objects	7,331.51	363.61
Hitchcock, Albert S., library fund, for care of the Hitchcock Agrostological Library	1,760.24	87.28
Hodgkins fund, specific, for increase and diffusion of more exact knowledge in regard to nature and properties of atmospheric air	100,000.00	6,000.00
Hrdlička, Aleš and Marie, fund, to further researches in physical anthropology and publication in connection therewith	37,141.61	1,755.02
Hughes, Bruce, fund, to found Hughes alcove	21,352.84	1,059.01
Loeb, Morris, bequest fund, for furtherance of knowledge in the exact sciences	97,222.19	3,234.01
Long, Annette and Edith C., fund, for upkeep and preservation of Long collection of embroideries, laces, and textiles	605.70	30.01
Maxwell, Mary E., fund, for care and exhibition of Maxwell collection	21,880.76	1,085.17
Myer, Catherine Walden, fund, for purchase of first-class works of art for use and benefit of the National Collection of Fine Arts	21,145.78	1,048.70
Nelson, Edward W., fund, for support of biological studies	9,887.88	267.19
Noyes, Frank B., fund, for use in connection with the collection of dolls placed in the U. S. National Museum through the interest of Mr. and Mrs. Noyes	1,071.75	53.13
Pell, Cornelia Livingston, fund, for maintenance of Alfred Duane Pell collection	8,268.85	410.08
Poore, Lucy T. and George W., fund, for general use of the Institution when principal amounts to $250,000	166,480.45	8,130.99
Rathbun, Richard, memorial fund, for use of division of U. S. National Museum containing Crustacea	11,864.80	588.42
Reid, Addison T., fund, for founding chair in biology, in memory of Asher Tunis	31,733.87	1,690.11
Roebling Collection fund, for care, improvement, and increase of Roebling collection of minerals	134,632.03	6,677.22
Rollins, Miriam and William, fund, for investigations in physics and chemistry	104,746.00	5,195.00
Smithsonian employees' retirement fund	29,772.26	1,526.41
Springer, Frank, fund, for care and increase of the Springer collection and library	20,004.71	992.14
Strong, Julia D., bequest fund, for benefit of the National Collection of Fine Arts	11,153.62	553.16

Fund	Investment	Income present year
Walcott, Charles D. and Mary Vaux, research fund, for development of geological and paleontological studies and publishing results thereof	$501,991.73	$24,743.49
Walcott, Mary Vaux, fund, for publications in botany	64,573.03	3,202.58
Younger, Helen Walcott, fund, held in trust	67,094.47	3,491.90
Zerbee, Frances Brinckle, fund, for endowment of aquaria	1,038.16	52.48
Total	1,898,204.07	93,149.71

FREER GALLERY OF ART FUND

Early in 1906, by deed of gift, Charles L. Freer, of Detroit, gave to the Institution his collection of Chinese and other Oriental objects of art, as well as paintings, etchings, and other works of art by Whistler, Thayer, Dewing, and other artists. Later he also gave funds for construction of a building to house the collection, and finally in his will, probated November 6, 1919, he provided stock and securities to the estimated value of $1,958,591.42, as an endowment fund for the operation of the Gallery.

The above fund of Mr. Freer was almost entirely represented by 20,465 shares of stock in Parke, Davis & Co. As this stock advanced in value, it was sold and the proceeds reinvested so that the fund now amounts to $6,936,185.15.

SUMMARY OF ENDOWMENTS

Invested endowment for general purposes	$1,816,977.98
Invested endowment for specific purposes other than Freer endowment	1,898,204.07
Total invested endowment other than Freer	3,715,182.05
Freer invested endowment for specific purposes	6,936,185.15
Total invested endowment for all purposes	10,651,367.20

CLASSIFICATION OF INVESTMENTS

Deposited in the U. S. Treasury at 6 percent per annum, as authorized in the U. S. Revised Statutes, sec. 5591		$1,000,000.00
Investments other than Freer endowment (cost or market value at date acquired):		
Bonds	$961,522.64	
Stocks	1,679,015.88	
Real estate and mortgages	5,981.00	
Uninvested capital	68,662.53	
		2,715,182.05
Total investments other than Freer endowment		3,715,182.05

CLASSIFICATION OF INVESTMENTS—Continued

Investments of Freer endowment (cost or market value at date acquired):		
Bonds	$4,016,765.54	
Stocks	2,666,410.11	
Uninvested capital	253,009.50	
		$6,936,185.15
Total investments		10,651,367.20

CASH BALANCES, RECEIPTS, AND DISBURSEMENTS DURING FISCAL YEAR 1954[1]

Cash balance on hand June 30, 1953		$533,830.34
Receipts, other than Freer endowment:		
Income from investments	$213,033.23	
Gifts and contributions	263,265.56	
Books and publications	37,361.68	
Miscellaneous	12,494.54	
Proceeds from real estate	90.00	
Payroll withholdings and refund of advances (net)	1,250.83	
U. S. Government and other contracts (net)	8,815.16	
Proceeds from sale of securities (net)	91,083.76	
Proceeds from sale of cash securities (net)	1,786.57	
Total receipts other than Freer endowment		629,181.33
Receipts from Freer endowment:		
Income from investments		324,659.98
Total		1,487,671.65
Disbursements other than Freer endowment:		
Administration	$93,554.50	
Publications	22,030.31	
Library	341.08	
Custodian fees and servicing securities	4,208.75	
Miscellaneous	948.09	
Researches	212,466.51	
S. I. Retirement System	2,531.04	
Total disbursements other than Freer endowment		336,080.28
Disbursements from Freer endowment:		
Salaries	$119,018.53	
Purchases for collection	131,452.25	
Custodian fees and servicing securities	11,752.58	
Miscellaneous	21,696.91	
Total disbursements from Freer endowment		283,920.27
Total disbursements		620,000.55
Cash balance June 30, 1954		867,671.10
Total		1,487,671.65

[1] This statement does not include Government appropriations under the administrative charge of the Institution.

ASSETS

Cash:			
United States Treasury current account	$695,472.72		
In banks and on hand	172,198.38		
	867,671.10		
Less uninvested endowment funds	321,672.03		
		$545,999.07	
Travel and other advances		8,274.82	
Cash invested (U. S. Treasury notes)		705,260.92	
			$1,259,534.81
Investments—at book value:			
Endowment funds:			
Freer Gallery of Art:			
Stocks and bonds	$6,683,175.65		
Uninvested cash	253,009.50		
		6,936,185.15	
Investments at book value other than Freer:			
Stocks and bonds	2,571,670.69		
Uninvested cash	68,662.53		
Special deposit in U. S. Treasury at 6 percent interest	1,000,000.00		
Other stocks and bonds	68,867.83		
Real estate and mortgages	5,981.00		
		3,715,182.05	
			10,651,367.20
			11,910,902.01

UNEXPENDED FUNDS AND ENDOWMENTS

Unexpended funds:			
Income from Freer Gallery of Art endowment			$526,109.19
Income from other endowments:			
Restricted		$262,673.44	
General		172,917.79	
			435,591.23
Gifts and grants			297,834.39
			1,259,534.81
Endowment funds:			
Freer Gallery of Art		$6,936,185.15	
Other:			
Restricted		1,898,204.07	
General		1,816,977.98	
			10,651,367.20
			11,910,902.01

The practice of maintaining savings accounts in several of the Washington banks and trust companies has been continued during the past year, and interest on these deposits amounted to $1,480.60.

In many instances, deposits are made in banks for convenience in collection of checks, and later such funds are withdrawn and deposited in the United States Treasury. Disbursement of funds is made by check signed by the Secretary of the Institution and drawn on the United States Treasury.

The Institution gratefully acknowledges gifts and grants from the following:

Laura D. Barney, additional gift for the Alice Pike Barney memorial fund.
Wenner-Gren Foundation, grant for La Venta exploration.
Edward W. Nelson Estate, to support biological studies.
National Geographic Society, for publication of "The Material Culture of Pueblo Bonito."
Morris Loeb Estate, for the furtherance of knowledge in the exact sciences.
Johns Hopkins University, for publications on Arctic research.
Link Foundation, for publication of a National Air Museum booklet.
E. A. Link, Link Aviation, Inc., additional gift for historical research (marine archeology).
Aircraft Industries Association of America, Inc., and Air Transport Association of America, for an architectural survey for the new proposed Air Museum.
Pan American Sanitary Bureau, for publication of manuscript by Herbert T. Dalmat on Guatemalan black flies.
Herbert Sondheim and the Washington Fashion Group, for research on historic dresses.
Agnes Chase, for copying the index to grass names.
Gene M. Stirling, for work on archeology and ethnology of Florida.
Time, Incorporated, for special paleontological work.
Guggenheim Foundation, for wax metabolism fund.
Rose Banon.
Robert M. de Calry.
Deere & Company, for E. C. Kendall.
Atomic Energy Commission, additional gift for studies on the regulation of plant growth by radiation.
Atomic Energy Commission, for study of mechanism of action of ionizing radiation.
United States Information Agency, for exhibition of "American Primitive Paintings."
United States Information Agency, for exhibition of "American Indian Paintings."
United States Information Agency, for five exhibits to be circulated abroad.
Frank Wilbert Stokes fund, for acquisition of certain paintings, sketches, and other artistic compostions.
For support of the Bio-Sciences Information Exchange:
Atomic Energy Commission
Department of the Air Force
Department of the Army
Department of the Navy
National Science Foundation
Public Health Service
Veterans Administration

The foregoing report relates only to the private funds of the Institution.

The following appropriations were made by Congress for the Government bureaus under the administrative charge of the Smithsonian Institution for the fiscal year 1954:

Salaries and expenses	$3,000,000.00
National Zoological Park	625,000.00

In addition, funds were transferred from other Government agencies for expenditure under the direction of the Smithsonian Institution as follows:

Working fund, transferred from the District of Columbia government, for the National Zoological Park	$35,000.00
Working funds, transferred from the National Park Service, Interior Department, for archeological investigations in river basins throughout the United States	71,495.00

The Institution also administers a trust fund for partial support of the Canal Zone Biological Area, located on Barro Colorado Island in the Canal Zone.

The report of the audit of the Smithsonian private funds follows:

WASHINGTON, D. C., *August 26, 1954.*

TO THE BOARD OF REGENTS,
SMITHSONIAN INSTITUTION,
Washington 25, D. C.

We have examined the accounts of the Smithsonian Institution relative to its private endowment funds and gifts (but excluding the National Gallery of Art and other departments, bureaus or operations administered by the Institution under Federal appropriations) for the year ended June 30, 1954. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

The Institution maintains its accounts on a cash basis and does not accrue income and expenses. Land, buildings, furniture, equipment, works of art, living and other specimens and certain sundry property are not included in the accounts of the Institution.

In our opinion, the accompanying financial statements present fairly the position of the private funds and the cash and investments thereof of the Smithsonian Institution at June 30, 1954 (excluding the National Gallery of Art and other departments, bureaus or operations administered by the Institution under Federal appropriations) and the cash receipts and disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

PEAT, MARWICK, MITCHELL & CO.

Respectfully submitted.

CLARENCE CANNON
VANNEVAR BUSH
ROBERT V. FLEMING
Executive Committee.

GENERAL APPENDIX

to the

SMITHSONIAN REPORT FOR 1954

ADVERTISEMENT

The object of the GENERAL APPENDIX to the Annual Report of the Smithsonian Institution is to furnish brief accounts of scientific discovery in particular directions; reports of investigations made by staff members and collaborators of the Institution; and memoirs of a general character or on special topics that are of interest or value to the numerous correspondents of the Institution.

It has been a prominent object of the Board of Regents of the Smithsonion Institution from a very early date to enrich the annual report required of them by law with memoirs illustrating the more remarkable and important developments in physical and biological discovery, as well as showing the general character of the operations of the Institution; and, during the greater part of its history, this purpose has been carried out largely by the publication of such papers as would possess an interest to all attracted by scientific progress.

In 1880, induced in part by the discontinuance of an annual summary of progress which for 30 years previously had been issued by well-known private publishing firms, the Secretary had a series of abstracts prepared by competent collaborators, showing concisely the prominent features of recent scientific progress in astronomy, geology, meteorology, physics, chemistry, mineralogy, botany, zoology, and anthropology. This latter plan was continued, though not altogether satisfactorily, down to and including the year 1888.

In the report of 1889, a return was made to the earlier method of presenting a miscellaneous selection of papers (some of them original) embracing a considerable range of scientific investigation and discussion. This method has been continued in the present report for 1954.

Reprints of the various papers in the General Appendix may be obtained, as long as the supply lasts, on request addressed to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D. C.

The Nature of the Upper Atmosphere[1]

By H. S. W. Massey

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Three vital functions are performed by the atmosphere—thermal insulation, removal of lethal ultraviolet light from solar radiation, and the volatilization of meteors. The ultraviolet absorption takes place mainly at an altitude between 20 and 40 km., where there is a concentration of ozone. The volatilization of meteors, on the other hand, takes place at about 100 km. The thermal effects of the atmosphere depend on its properties over a wide range of altitude. This is because a number of processes are involved—absorption of the short-wave solar radiation, which takes place at great heights, its degradation to long wavelength heat radiation, and the subsequent effects of these heat waves.

There are a number of other important upper atmospheric phenomena, and it is perhaps best to start by summarizing them as they would be encountered in the course of ascent from the ground (fig. 1). After one passes through the troposphere, the stratosphere is reached at a height of about 12 km. At about the same altitude the primary cosmic rays, consisting mainly of very energetic protons as well as other nuclei, are strongly absorbed, producing the bewildering multitude of secondary particles the study of which forms one of the main branches of fundamental research in physics. The next region of importance is the ozone layer. At 70 km. an unexpected constituent becomes apparent, namely sodium. Although present in only minute concentration this sodium makes an important contribution to airglow effects. Some 10–15 km. higher there are encountered for the first time regions in which there is an appreciable concentration of ions and electrons; that is to say, the concentration is large enough to influence the propagation of radio waves. This ionized region, known as the D region, can be a source of radio fadeouts at times, especially during periods of intense solar activity, when the ionization in the region is much enhanced.

[1] Reprinted by permission from Endeavour, vol. 13, No. 50, April 1954.

At 100 km. the threshold of several important regions is reached; at this height the pressure is only about 10^{-7} of that at ground level. The temperature, having passed through two peaks and a trough, ranging from 180° K. at 80 km. to 270° K. at 50 km., is here about 240° K. The composition of the air, as far as the major constituents are concerned, is still much the same as at ground level; about four-fifths consists of molecular nitrogen and most of the rest of molecular oxygen.

At a slightly greater altitude an important change rapidly sets in—the oxygen becomes predominantly atomic. This produces considerable changes in the absorbing power of the oxygen for solar radiation, and also makes possible certain light-emission processes which are important in determining the color of the night air-glow.

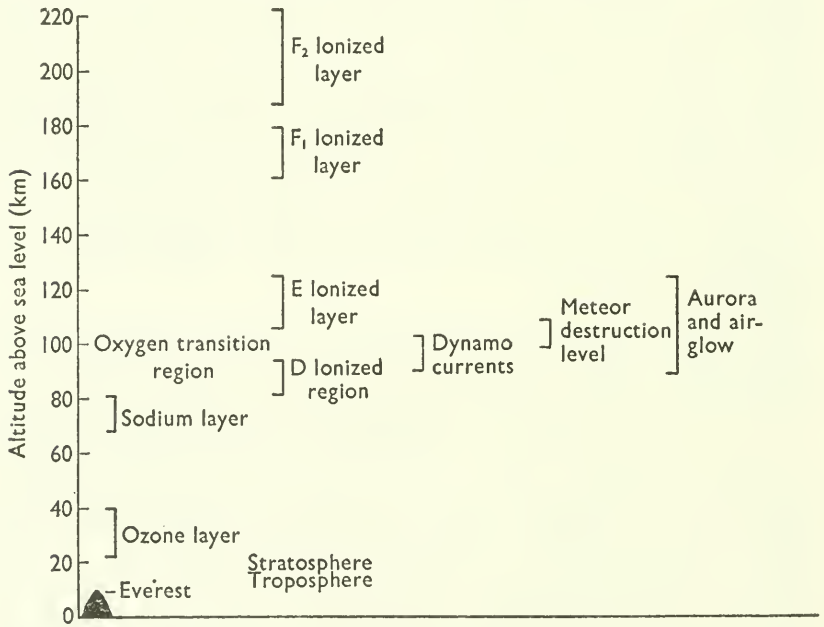


FIGURE 1.—Schematic representation of the high atmosphere exhibiting the main regions of interest. (Note that the F_1 and F_2 ionized layers are shown separately. They are so only in daytime, merging at night.)

Another technically important ionized layer is located between the 100 km. and 120 km. levels. It is a relatively thin (5–6 km.) one, known as the E layer. Its electron concentration is considerably higher than that of the D region and the absorption very much less, so that the reflection of radio waves from the E layer plays an important part in long-distance radio propagation.

It seems probable that the main atmospheric currents that are responsible for the so-called steady lunar and solar magnetic variations flow in, or just below, the E layer. These currents result from the

effect of atmospheric tidal motions on the E-region ionization, and they demonstrate the periodicity of these tides.

Many of the most interesting atmospheric light-emission phenomena arise from levels in the neighborhood of 100 km. The night air-glow occurs throughout the year and shows little variation with latitude. It consists largely of the green and red line emission from atomic oxygen, and band emission from molecular nitrogen and from hydroxyl. The height of the emitting regions is probably not far from 100 km.

A more spectacular optical phenomenon is the aurora. This is much more intense than the night air-glow, and is concentrated in the so-called auroral latitudes—there is a maximum frequency of occurrence for the aurora borealis in a magnetic latitude of 67°, with a corresponding maximum in the southern hemisphere for the aurora australis. The auroral light includes strong emission at the wavelengths of the green and red oxygen lines, as in the air-glow, but the strong band emission is from ionized, not neutral, molecular nitrogen. In the latitudes of most frequent occurrence the main light emission is from altitudes close to 100 km. At lower latitudes the much less frequent aurorae often occur at higher altitudes, some as high as 600 km. Magnetic storms are usually associated with auroral displays, and radio propagation is disturbed.

As pointed out earlier, the 100-km. region is also the crematorium of most meteors. So many of them are volatilized near the same level that they produce a considerable concentration of ionization, often referred to as the sporadic, as distinct from the normal, E layer, which is at a slightly lower altitude.

There is still sufficient atmosphere well above 100 km. to be of importance in many ways. Above 120 km. the concentration of electrons and ions forming the E layer falls off, quite rapidly at first, but then begins to increase again, and by day reaches a new and larger maximum at about 160–170 km. This corresponds to the F_1 layer.

After passing above this altitude, the ionization soon ceases to decrease, and then increases again to form the very broad F_2 layer in which the electron concentration is ten times as great as the maximum in the E layer. At night the F_1 layer merges with the F_2, and there is an upward movement of the ionization to form the F layer which plays a vital part in long-distance radio propagation. At 160 km. the atmospheric pressure is about 3×10^{-9} of that at ground level, while the temperature is perhaps 750° K. This upward trend in temperature almost certainly continues, so that well within the F_2 layer it probably exceeds 750° K.

Our knowledge about the upper atmosphere has been gained by a combination of direct and indirect observation. Until the last few years no direct methods were possible, but the recent remarkable de-

velopments in rocket propulsion have made it possible to carry instruments up to heights of as much as 200 km. to make direct measurements of local conditions in the high atmosphere.[2] Because of the peculiar difficulties associated with use of rocket-transported instruments, the methods of observation often have to be very different from those that would normally be used in a laboratory measurement. Considerable ingenuity has been exercised in the design of rocket experiments and very important new results are now emerging. It is interesting and encouraging to note that, at least below 100 km., direct observations made by the use of rockets has largely confirmed the deductions from the indirect methods. The technique developed by Paneth and his coworkers for the microanalysis of gases (Endeavour, vol. 12, p. 5, 1953) has proved very useful in investigating samples of air recovered from rockets sent to great heights.

PRESSURE, TEMPERATURE, AND COMPOSITION

If the composition of the atmosphere is known at any altitude, measurements of any two of the three quantities pressure (p), density (ρ), and temperature (T) enable the third to be deduced. Up to about 100 km. it is probable that there is no appreciable change of composition from that at ground level, and this is consistent with the observations of p, ρ, and T by various methods.

The pressure and density have been measured directly up to altitudes as high as 200 km. The pressure is determined by suitable pressure gages (bellows gages for low altitudes and ionization gages for the high ones) inserted on the sides of a rocket near the tail fins. Windtunnel tests have confirmed that such gages measure the ambient pressures. The density is determined from the stagnation pressure, measured by a suitable pressure gage at the nose of the rocket. The mean values of results obtained to date are given in figure 2.

The temperature variation has been determined by several methods. If the velocity, v, of sound can be obtained, the temperature can be calculated from the relation

$$v^2=\gamma RT/M$$

where R is the universal gas constant, M the average molecular weight of the air, and γ the ratio of the specific heats of the gas. The first way in which this possibility was utilized concerned the so-called anomalous propagation of sound. Intense sounds, such as those of gunfire, are often heard at great distances from the source, beyond an intervening zone of silence. This is because sound waves traveling at large inclinations to the horizontal are reflected by a high-temperature region, in

[2] A detailed account of investigations of this kind will be found in the Proceedings of the Oxford Conference on Rocket Exploration of the Upper Air, Pergamon Press, London, 1954.

which their velocity is increased, and thus return to earth at a distant point. The phenomenon is essentially similar to long-range radio propagation (see fig. 3). The distance from the source to the point where the reflected rays, returning from different directions, are received gives the height of the reflecting high-temperature layer. Recently a more precise sound-ranging method has been introduced for use with rockets. At suitable heights grenades were ejected from a

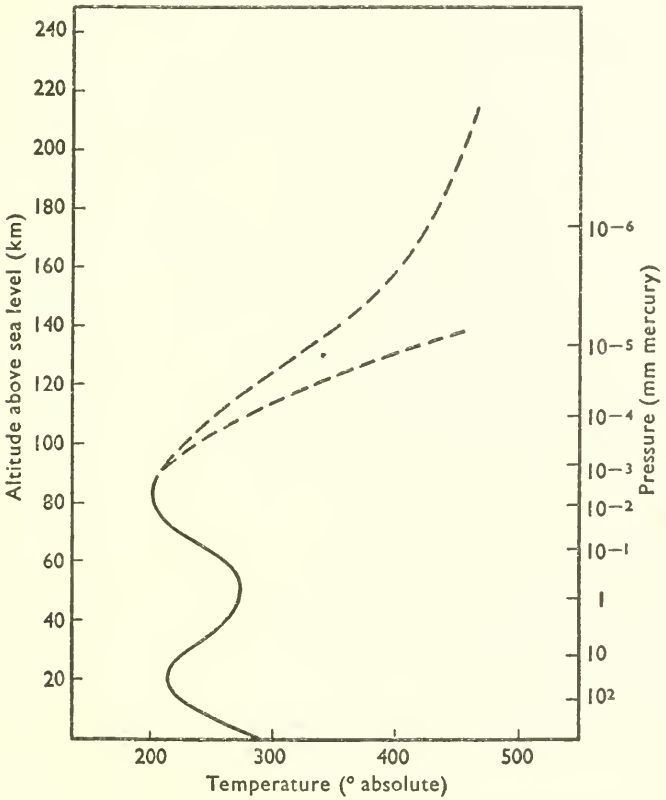


FIGURE 2.—Pressure and temperature in the atmosphere as a function of height. The full line is obtained directly from the mean rocket observations made at White Sands, N. Mex. Above 100 km. there is uncertainty in deriving the temperature from the pressure and density, owing to changes in composition. The dotted lines indicate two results obtained on two extreme assumptions.

rocket in flight and exploded. The explosions were photographed and the arrival of the sound pulses at each of five ground stations was accurately timed. From these observations the location of the explosion, the velocity of sound at different levels, and the distribution of atmospheric winds could be determined. An alternative method for measuring the speed of sound by rocket is from determination of the ratio of the pressures measured by two gages located on the side of the rocket at

different distances from the nose. This gives the Mach number of the flow past the rocket, and hence the speed of sound.

Indirect evidence about the temperature distribution has been obtained from a study of atmospheric tides. It has been found from radio observations (see below) that the amplitude of the lunar tidal oscillations is greatly enhanced at the level of the E layer. The amplitude and phase of these oscillations at high levels are quite sensitive to the temperature distribution, and Weekes and Wilkes [1] [3] were able to show theoretically that up to 100 km. the general form must be that shown in figure 2.

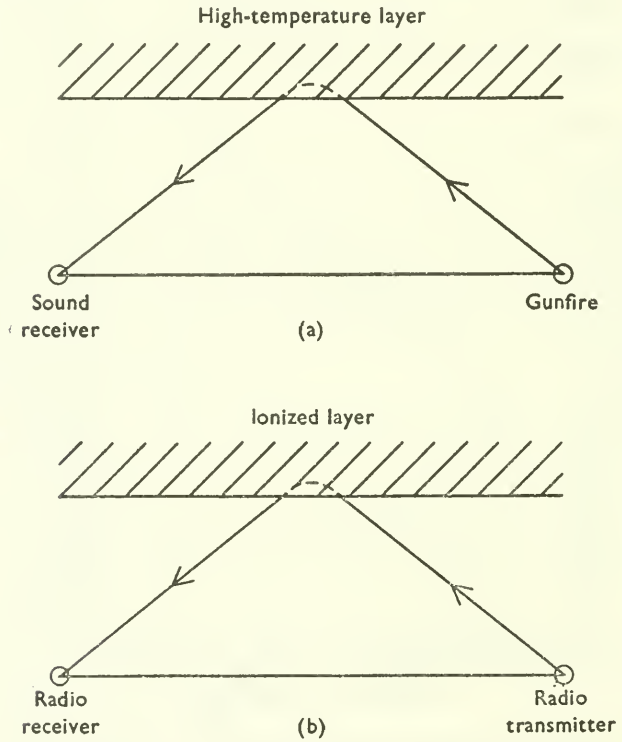


FIGURE 3.—Illustrating the long-range propagation of radio and sound waves.

Finally, it has been possible to obtain information about the temperature in the E and F layers by determination, by means of radio, of the variation of electron density with height. The scale height H, which is the distance above a given level at which the pressure has fallen to $1/e$ of its value at that level, is given by $H=RT/Mg$, where R, T, and M are as previously defined and g is the acceleration due to gravity. Assuming the atmospheric composition, the temperature T may be deduced if H is known. Allowance must be made for dissocia-

[3] Numbers in brackets indicate references at end of text.

tion of the oxygen above 100 km. and possibly of the nitrogen also at higher levels.

Figure 2 illustrates our present knowledge about the temperature variation at different heights. Above 100 km. there is considerable uncertainty due to uncertainty about the degree of dissociation of nitrogen. No direct measurements are yet available at these great heights.

THE IONIZED LAYERS

A great deal of research on the properties of the atmosphere in the E and F layers has been carried out by radio methods. The mechanism of long-distance propagation of radio waves is roughly as illustrated in figure 3, which shows a reflecting ionized layer. Furthermore, when radio waves of wavelength λ enter an ionized layer normally they are totally reflected at a level where the electron concentration n attains the value $\pi mc^2/e^2\lambda^2$, where e is the charge and m the mass of an electron and c is the velocity of light. By measuring the time delay between vertical transmission of a ray of given wavelength and reception of the reflected wave, it is possible to determine the variation of n with height in a particular level until the observed wavelength is that for which n attains its maximum value in the layer. Further increase of wavelength then leads to complete penetration of the layer. Rocket methods now make it possible to trace the variation beyond this maximum. The method is to measure the local velocity of a radio wave by observation of the Doppler effect, due to the velocity of the rocket, on a radio signal transmitted from the rocket. The proportional Doppler shift in frequency is given by v/V, where v is the velocity component of the rocket in the direction of observation and V the phase velocity of the radio wave transmitted from the rocket in the atmosphere round the rocket. V is given by

$$\left(1-\frac{ne^2\lambda^2}{\pi mc^2}\right)^{-\frac{1}{2}}c,$$

where c is the velocity of light (total reflection occurs effectively where $V\to\infty$).[4]

For a long time data of great accuracy have been obtained by radio methods using many ground stations distributed over a wide range of latitude; rocket observations, on the other hand, have hitherto been limited.

As mentioned earlier, radio-sounding methods have given information about the temperature distribution and the tidal motions at great heights. The latter observations depend on careful studies of fluctua-

[4] This formula neglects the effect of the earth's magnetic field, which modifies the situation considerably.

tions observed in signals from the ionized layers. These layers are far from uniform. They have a granulated structure, and the motion of the granules, which are quite large, may be deduced from analysis of signal irregularities.

The ionized layers are produced by electromagnetic radiations from the sun. A given ionizing radiation will produce electrons at an increasing rate per unit volume as it penetrates into denser and denser atmospheric regions, until absorption begins to be large; after this point it will decrease to zero, when the absorption is complete. The particular radiations responsible for the main ionized layers are still not identified with certainty. It is of interest to note, however, that by sending up in rockets counters sensitive to X-rays, definite evidence has been obtained that, at E-region levels, there are sufficient soft X-rays in the solar radiation to produce the E-region ionization. It was suggested some time earlier by Hoyle and Bates [2] that X-rays emitted from the solar corona might be responsible for the E layer. The F ionization may be due to ionization of atomic oxygen by short ultraviolet radiation, but this is far from certain. There is no doubt, however, from evidence obtained by observing the delay between obscuration of the solar disk and the onset of ionospheric changes during a solar eclipse, that the main layers are due to radiations traveling from the sun with the velocity of light.

The tidal motion of the upper atmosphere exerts dynamical forces on the electrons and ions in the ionized layers, producing a current system, the nature of which is complicated by the earth's magnetic field. According to the dynamo theory, first suggested by Balfour Stewart [3] as early as 1883, the tidal flow across the field produces a current in a direction perpendicular to each. The magnetic field at ground level includes a contribution from the field of this current system, and this will vary periodically with the tidal motion. These magnetic variations exhibit components varying with the lunar and solar tidal periods. Recent theoretical work has produced strong confirmation of the dynamo theory. Singer, Maple, and Bowen [4] performed a remarkable experiment with a rocket carrying a total-field magnetometer so that the variation of field with altitude could be measured. In passing through a current layer there should be a sudden decrease in field. Such a decrease was found to occur at an altitude of 93 km. (fig. 4), about the expected altitude of the base of the dynamo current layer.

THE AURORA AND AIR-GLOW

There is a clear correlation between the onset of an auroral display and the occurrence of disturbed conditions on the sun. However, unlike the ionospheric-solar relation, there is a time lag of one or two days between the onset of the solar disturbance and that of the aurora.

This rules out solar electromagnetic radiation as the direct causative agency. The alternative is a stream of corpuscles. This cannot consist of charged particles of one sign, as their mutual repulsion would disperse the stream long before the earth was reached. It is supposed that the stream is an ionized one containing protons and electrons in equal concentration. Strong evidence for the presence of protons in the incident stream has been afforded by the observations of Gartlein [5] and of Meinel [6] of broad hydrogen lines in the auroral spectrum. The broadening is due to a Doppler effect which would be expected if the lines were produced by fast incoming protons capturing electrons from atmospheric atoms, and if some of these electrons were captured into excited states. Radiation due to transitions from these states would account for the observations.

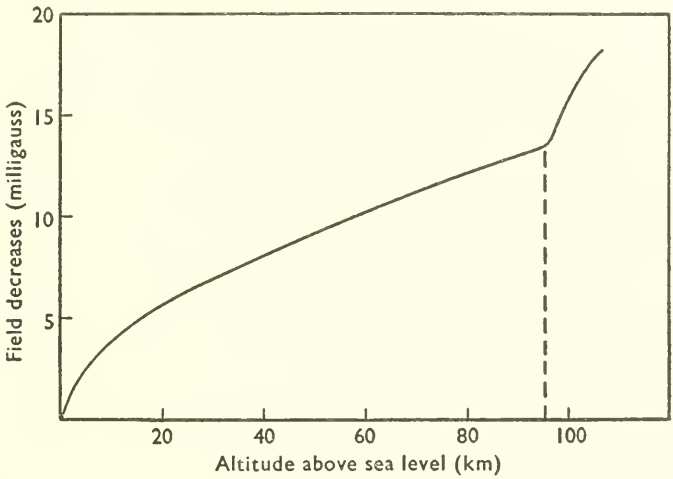


FIGURE 4.—Observed decrease of magnetic field with height off the coast of Peru, using a rocket-borne magnetometer. The sudden increase in the rate of fall of the field at 93 km. indicates the presence of a current layer at that altitude.

There are a great number of problems still unsolved concerning auroral phenomena. In some way the protons in the corpuscular stream must be speeded up near the earth; if they had throughout their journey the speed calculated from the time delay of auroral onset they would not be energetic enough to penetrate to the levels at which the auroral hydrogen lines are observed. The reason for the concentration of auroral effects in a narrow belt of latitude in each hemisphere is also far from clear.

The night air-glow is a more or less steady emission of light from the sky during the night, apart, of course, from starlight and any moonlight. It is much weaker than the aurora and involves much less energy. It is almost certainly due to transfer of some of the energy stored up from sunlight during the day into radiation in the far

infrared, visible, and near ultraviolet. Thus, during the day the sunlight dissociates molecular oxygen. Partial recombination of the resulting atoms during the night will involve processes in which light may be emitted. It is of interest to note that the yellow D lines of sodium are quite prominent in the air-glow spectrum, even though the proportion of sodium at its maximum concentration is less than 10^{-8} of the main atmospheric constituents. The intensity of emission is so high that Bates has suggested that an observable enhancement might be achieved by conveying a can of sodium to the required altitude by rocket and dispersing the metal there. A day air-glow has been observed by rocket methods at altitudes above 40 km. where scattered light from the lower atmosphere is sufficiently weak. Detailed spectroscopic observation of this air-glow has not yet been carried out.

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Solar Influence on the Earth[1]

By John W. Evans

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Although the sun is the great provider of the necessities for life, most of us know rather little about it simply because it is so thoroughly reliable. We do not have to worry about whether we shall receive our daily quota of solar energy tomorrow. A very long history of unfailing performance justifies the belief that we shall. In fact, an astronomer friend recently offered to bet me a dollar at odds of 10 to 1 that the sun would still be shining 1 billion years from now. He made the proviso that he should hold the stakes. After computing the interest on $1 for 1 billion years, I decided that this was a mere swindle. The winning of the bet pales into insignificance compared to the compound interest on a dollar for a billion years—a figure so large that even our Government has not found a name for it.

Since the sun is so reliable we devote our worries to more worthy problems, such as whether it will rain in Texas, or whether the Senators can beat the Yankees, since these matters are highly uncertain. There are, however, a few peculiar sun worshipers residing on mountain peaks and at other odd places, surrounded by telescopes and spectroscopes and radio gadgets, who take the sun very seriously. They are finding that in some things the sun is very capricious and quite unreliable. Until recently this had so little effect on our daily lives that we were not even aware of it. But with the rising complexity of our technology and our dependence on delicate devices that are vulnerable to small disturbances, we are becoming increasingly aware of the effects of these minor solar variations, although most of us do not recognize the sun as the root of our troubles. It is these minor solar variations and their terrestrial effects that concern us here.

I am sure you are familiar with the effect of fading on your radios. Usually stations come in strong and clear from tremendous distances,

[1] Twenty-first James Arthur lecture, given under the auspices of the Smithsonian Institution on May 27, 1954.

but once in a while the signal fades out and all you can get are local stations within 100 miles or so. While parents of teenage youngsters may regard this as a blessing, the pilot of a transatlantic airplane is apt to disagree. Whether we like it or not, this fading-out of distant radio stations is traceable to the sun. What happens is something like this:

Radio waves are like light. If not disturbed they go in straight lines, and if nothing interfered, we could not receive them any farther away than we can see. In fact, the short high-frequency waves of television have this property, which is the reason a given television station can serve only a small area within 25 or 30 miles. The longer waves of the broadcast band however, can be transmitted to the other side of the world. To get there, they have to travel around the curve of the earth in anything but a straight line-of-sight path. This is possible because the ionosphere serves as a highly reflecting mirror to long radio waves, which bounce back and forth between it and the ground and are thus conducted around the curve of the earth.

That word "ionosphere" is very important in any explanation of solar terrestrial effects. In broadest terms, the ionosphere is that portion of our upper atmosphere which is capable of conducting electricity. Its normal lower limit is some 60 miles above the ground, where the density of the air is less than a millionth of that at ground level, and it extends upward to about 130 miles.

The atmosphere at all heights is composed of myriads of tiny particles known as molecules. There are so many of them that when you take a good deep breath you can be quite sure of inhaling a couple of hundred that were breathed out by Patrick Henry in uttering the words "Give me Liberty or give me death," and have since been thoroughly mixed with the whole atmosphere of the earth. The thought would perhaps be a little unappetizing if Patrick Henry had not used that breath so effectively. Its significance is simply that there are about 200 times as many molecules in a single breath as there are lungfuls of air in the whole of the earth's atmosphere. What I am trying to say is that the molecules of the atmosphere are tiny and numerous. Furthermore they are complicated. They are made up usually of two atoms of oxygen or nitrogen, held together by electric bonds. When one of these molecules is given a sufficient jolt it comes apart. Sometimes the two atoms are separated. When this happens one of the atoms may steal an electron from the other, and both then have an electric charge. Sometimes the jolt merely removes an electron without otherwise disturbing the molecule. Either of these processes is called ionization. The particles resulting from ionization are known as ions and free electrons. Their important property is that they carry a small electric charge and therefore can be pushed around by electric forces, unlike normal molecules.

The ionosphere gets its name and its electrical conductivity from the fact that it contains an appreciable fraction of ions and free electrons. As many as one molecule in every 10,000 may be ionized. It is actually the free electrons that reflect long radio waves. The process of reflection is too complicated to explain here, but I will ask you to endure a crude analogy. Think of the electrons in the ionosphere as an ionospheric screen, like a window screen. The fineness of the mesh of our screen is proportional to the number of electrons per cubic inch in the ionosphere. When radio waves hit the screen, they are caught and thrown back if they are larger than the mesh, but if they are smaller they pass through between the electrons, so to speak, to outer space. Thus the long waves of the broadcast band are reflected, and can be received over long distances around the curve of the earth, while the short TV waves are not reflected, but penetrate through the ionospheric screen, for the benefit of inhabitants of artificial earth satellites and the moon. The ionospheric screen has one other property that is directly responsible for radio fading. Under normal conditions there is good reflection from it when it is in the high atmosphere where the electrons have room to shake themselves without too much interference from neighboring molecules. But if for some reason the screen is pushed down to low levels where there may be a hundred times as many molecules per cubic inch, the screen gets clogged and the radio waves are neither reflected nor transmitted. They are absorbed, and distant stations fade out. The energy of the radio waves stops right there and goes into warming the air. I am sure this fact is not generally known in the halls of Congress. If it were, and our legislators realized that under special conditions they could warm the air of the upper atmosphere while warming that in their immediate vicinity, the condition of the ionosphere would be fixed by law, since any presidential veto would surely be overridden.

While the fading of radio signals is the most familiar solar effect, whether we recognize it as such or not, there are others which I shall discuss presently. The noteworthy fact is that all of them can be traced to disturbances in the ionosphere, and we may justly conclude that the primary solar terrestrial effect from which all observable effects stem, is the influence of the sun on the ionosphere. Now, just what is this influence?

The thing that counts in the ionosphere is the concentration of ions—the number of ions per cubic inch—at various heights above the ground. Normal concentrations vary from about 1 to 3 million ions per cubic inch at different heights.

I have already mentioned that ions are formed when air molecules are subjected to sufficiently large jolts. In ordinary terms, the required jolt is very small. In climbing an inch up the wall a fly expends enough energy to ionize a thousand billion molecules. But

it is not altogether easy to ionize a molecule in spite of this. The trick is to concentrate the little bit of energy required on a single molecule. You cannot do it by swinging a baseball bat. The energy is there all right, but it gets spread around among billions of billions of molecules, and no single one of them gets enough to break it in two. The only two things that possess the required energy in sufficiently compact packages to be concentrated on single molecules are the bullets of ultraviolet light known as quanta, and fast-traveling atomic particles of several types, which are known collectively as corpuscles. The very existence of the ionosphere is sure evidence that the earth is being showered continuously with ultraviolet quanta or corpuscles or both. Until recently neither of these agents could be observed directly. They are completely absorbed in the process of forming the ionosphere and never reach the ground. To them the upper atmosphere is like a brick wall, and both ultraviolet quanta and corpuscles expend their energy on it in the process of forming ions. However, even though they were unseen, there were several good reasons for supposing that both corpuscles and quanta were involved in the formation of the ionosphere and that they all came from the sun. It did not take a Sherlock Holmes to pin it on the sun. There simply is no other likely source handy. Furthermore, it was observed that certain events on the sun were often followed by sudden large changes in the ionosphere with such perfect timing that there could be no doubt of a connection. The timing also gave the clue to the nature of the disturbing agents. When a flare flashed up on the solar surface, the ionosphere on the daylit side of the earth responded instantly. In other words, the disturbing agent had made the trip from the sun to the earth along a straight-line path and with the same speed as the light by which we saw the flare, and must therefore be ultraviolet quanta. Then about a day later a second and more prolonged ionospheric disturbance would set in all over the world long after the flare had died out and disappeared. The one-day time lag was interpreted as the time required for a shower of material corpuscles to travel the 93,000,000 miles from the sun. They were electrically charged and guided in to all parts of the earth by the earth's magnetic field. Hence, both quanta and corpuscles were involved. All this is a nice example of the power of careful step-by-step reasoning to explain phenomena that cannot be directly observed. First it was observed that radio waves were transmitted around the world, and Kennelly and Heaviside explained this by assuming the existence of the ionosphere. Then radio experiments were devised to specifically test this assumption—and it proved correct. It was realized that the ionosphere can be maintained only by incoming ultraviolet quanta or corpuscles; and again it was assumed that the sun must

be the source of these. Finally this was confirmed by observation of disturbances on the sun and corresponding disturbances in the ionosphere. Having got this far we have the main outlines of the activity without ever having seen it. As I have described it, it appears much less complicated than it actually was. The scientific method rarely runs smoothly. A theory is advanced. Investigators think it over and give it up, and think some more and give it up some more, until some key discovery convinces them that it is a good idea, or quite impossible. Then they are ready for the next step.

In the case of the ionosphere, theory has received brilliant observational confirmation in the last few years. Scientists of the Naval Research Laboratory and of the University of Colorado have sent rockets into the ionosphere from the White Sands Proving Grounds. They unequivocally recorded the ultraviolet radiation from the sun for the first time. A year or so earlier the incoming corpuscles were also observed directly at the Yerkes Observatory and at Cornell by spectroscopic means, and their velocities were found to vary from a few hundred to more than 2,000 miles/sec.

I think that by now you have anticipated me in seeing how the ionosphere is disturbed by the sun. Its existence is due to a steady stream of ultraviolet quanta and corpuscles from the sun. The intensity of this stream frequently varies violently. These variations cause changes in the density of ions at different heights in the ionosphere. To go back to our analogy, the height and mesh of the ionospheric screen is drastically altered, and detectable effects immediately follow. When the ionosphere is pushed downward into the denser regions of the atmosphere it becomes clogged and absorbs all radio signals, and we have fading.

Radio fading, however, is by no means the only result of abnormal ionospheric conditions. I have discussed it in detail because it probably affects more people than any of the others. The others are equally interesting, and usually result from some other kind of change than a depression of the ionospheric net into the gummy denser air of the lower levels.

The magnetic field of the earth is often affected, quite independently of radio fading. The compass needle points a trifle off its normal direction, and the strength of the field increases or decreases slightly. This is referred to as a magnetic storm. Without delicate magnetometers we would be quite unaware of the most violent magnetic storms because they stimulate none of our five senses. One manifestation of a magnetic storm, however, is often beautifully visible. This is the aurora. Ordinarily the aurora is confined to a narrow zone around the earth in the polar regions. It is a glow high in the ionosphere produced by corpuscular bombardment from the sun, like the bom-

bardment of neon in a neon sign by electrically propelled ions. The solar particles consist mostly of free protons and electrons, and are therefore electrically charged. As they approach the earth they enter its magnetic field which guides them in and concentrates them in the auroral zones around the north and south magnetic poles. Their collisions with air molecules excite the molecules to luminescence, which we see as the aurora. This is the normal state of affairs. When some disturbance on the sun sends out corpuscles at higher speed, they are less easily controlled by the terrestrial magnetic field, and strike the ionosphere in lower latitudes. Thus occasionally the aurora borealis will be seen from the latitude of Washington. When that happens you can be quite sure that a vigorous magnetic storm is in progress.

The exact ionospheric mechanism responsible for magnetic storms is still a matter of debate. However, we can say this much. Just as the earth's field exerts forces on the incoming solar corpuscles, equal and opposite forces are exerted on the field. This is an example of a very fundamental physical law which is so strikingly used in rocket propulsion. Next time you swing a cat by the tail, note that the cat pulls on you as hard as you pull on him. It is the same thing. The earth's magnetic field is quite elastic, and when the solar corpuscles give it a shove it gets pushed out of shape. If you will picture the earth's field as a vast framework of invisible elastic wires held together by the mysterious bonds that we call a field, it will not be too difficult to see that a distortion of this framework at one point will mean accommodating distortions throughout the whole, and at any one place the direction and tension of the wires will be changed. You would get a similar effect if you dropped a stone on a drumhead of balloon rubber. The distortion is greatest near the stone, but the shape of the drumhead is changed at every point. This distortion in the earth's field is what we detect as a magnetic storm and, like the rubber of the drumhead, it is different at different locations on the earth although all locations are affected simultaneously. Since the magnetic storms and abnormal aurorae are apparently caused by the same solar particles, the two always occur together. I hope there are no representatives of the Department of Terrestrial Magnetism present tonight. If there are, I fear for my scientific scalp, after such a simplification of a very complex matter.

One other solar effect is worth our attention. Occasionally when we have an especially intense disturbance in the ionosphere, it produces such powerful electric fields at ground level that wire communications fail. Transcontinental teletypes go completely crazy, and the messages received are nothing but a meaningless jumble of letters, which sometimes come through when no message is being sent at all.

Fortunately such spectacular disturbances are fairly rare and quite short-lived.

Because of the practical importance of ionospheric disturbances, particularly to radio communication, many agencies of the Government and industry are intensely interested in doing something about them. A few years ago I could have remarked that you cannot control the ionosphere any more than you can control the weather, but that would be an anachronism in this day of cloud-seeding experiments. The next best thing to making the ionosphere behave itself is to be able to predict its fits of misbehavior. This takes us directly to the cause of all ionospheric disturbances, the sun.

It is for this reason that the geophysics directorate of the Air Force Cambridge Research Center has just built a modern solar observatory at Sunspot, N. Mex., on Sacramento Peak, at 9,000 feet altitude. We know a lot about the sun, but the more we learn, the more we find that we ought to know and do not. In particular, we have learned of a few isolated kinds of solar activities that are associated with ionospheric storms, but so far no one has advanced an acceptable theory of how these activities produce the ultraviolet radiation and blasts of corpuscles that affect the earth. We are like the puppy who observes that the baby's explorations in the clothes closet are often followed by corporal punishment for Fido, an innocent bystander, with no apparent causal connection.

In order to save myself numerous small digressions later, I shall indulge in a long one now to describe the general characteristics of the sun. It is the central body of the solar system, at a distance of 93 million miles from the earth. It contains 99.8 percent of the material of the whole solar system, and to the outside observer the planets and comets revolving around it would appear as interesting but inconsequential trifles in comparison. The sun's diameter is over a hundred times that of the earth and its weight is 332,000 times as great. It is composed entirely of gas, because the temperature of even its coolest parts is so high that the most refractory materials are vaporized. Although it contains oxygen, no combustion takes place because of the same high temperature. Combustion is the chemical combination of atoms of oxygen with other atoms. The hot atoms of the solar gas move so fast and collide so violently that any two that happen to stick together are instantly knocked apart. Hence the heat and light of the sun are not due to any burning process. Instead, the source of energy is a thermonuclear reaction in the deep interior, which converts 4 million tons of the solar mass into energy every second. If this seems like an alarming rate of expenditure of solar material, I can only advise a relaxed attitude. The sun has enough expendable material to keep going at the same rate for a number of billions of years.

Although the ultimate source of energy is deep inside the sun, it is the leakage of this energy through the surface that interests us tonight in considering solar terrestrial effects. The surface has a temperature of about 10,000° F. It radiates a remarkably steady flow of light, the measurement of which has been a major part of the distinguished career of Dr. Abbot of the Smithsonian. He found that, within 1 or 2 percent, the solar energy that can be observed from the ground is constant. This is in marked contrast to the invisible ultraviolet radiations which maintain and are absorbed in the ionosphere.

If we look at the sun through a telescope at almost any time we find its surface pocked with sunspots, great dark circular patches that may be anything up to 100,000 miles in diameter. We know that they are cooler than the surrounding regions and they are the seats of stupendous magnetic fields, but their cause is a mystery. The most remarkable thing about the sunspots is the cyclic variation in their numbers. The sunspot cycle averages about 11½ years. At maximum, many spots are always visible on the solar disk, but at sunspot minimum no spots will be seen for days at a time.

When we equip our telescope with various spectroscopic devices, we can detect other solar features otherwise invisible. I have already mentioned the flares. They are especially important to students of solar terrestrial effects, because, of all solar activities, they are most clearly connected with the most violent and troublesome of ionospheric disturbances. A flare is a very impressive sight. Somewhere near a sunspot it suddenly appears as a small bright point of light on the solar surface. In a matter of minutes it flashes up to its maximum size and brightness, and then slowly fades away to invisibility in half an hour or so. Its full size is about like that of the sunspots, and may be anything from the smallest detectable up to 100,000 miles across. In visible light a flare is a puny thing, which cannot be seen at all without special optical aids that reject most of the light except that of the flare. This appearance, however, grossly belies the true potency of a flare, as the visible tip of an iceberg projecting above the sea belies the great bulk below the surface. It is clear that the great bulk of flare energy consists of ultraviolet quanta and corpuscles. This is evident from the reaction of our ionosphere. When a flare appears a new ionospheric screen very suddenly develops at a height of only about 40 miles, where the interference of air molecules becomes so great that no reflection of radio waves is possible. We have a radio fadeout. An estimate of the energy required shows that the ultraviolet output of a large flare, which might have an area of one-thousandth of the visible hemisphere of the sun, is comparable with the output of the whole normal sun. We conclude that each square inch of the flare would be 1,000 times as bright as a square inch of the normal solar surface, if we could see it in ultraviolet light.

We can draw a further conclusion. The low-level ionization produced by flare radiation appears without any serious changes in the normal ionosphere above 60 miles. In other words, the normal ionosphere, which is completely opaque to the ultraviolet of the normal sun, fails to absorb the quanta from the flare. They penetrate it quite freely and are absorbed in the process of producing ions at the 40-mile level. Hence there must be something different about flare quanta. The difference can only be a difference in wavelength of the radiation. If we were talking about visible light we would simply call it a difference in color, and I am going to refer to this wavelength difference as a difference in ultraviolet color.

The atmosphere of the earth contains many different kinds of molecules, and the percentage abundance of the different kinds varies with height above the ground. Each kind is an efficient absorber of some particular ultraviolet color. It absorbs this color and becomes ionized in doing so. The ultraviolet radiation from the normal sun encounters molecules of a kind that absorb its particular color at levels above 60 miles. They are not the kind of molecules that absorb radiation of the different ultraviolet color emitted by flares, however. Therefore this radiation penetrates to a lower level where it finds molecules of another kind, which forthwith absorb it and produce ions. Just which kinds of molecules and which colors are involved is still rather uncertain.

In addition to terrific bursts of ultraviolet quanta, flares emit equally impressive showers of corpuscles, consisting largely of free protons and electrons. They travel along at a rate of 1,000 miles/sec., and arrive at the earth about a day after the flare outburst. As they impinge on the earth's magnetic field they twist it slightly out of shape, and some of them are guided down into the ionosphere. We then have a lively magnetic storm, and aurorae appear in lower-than-normal latitudes.

Although the most spectacular of solar disturbances, flares are not the only ones to affect the ionosphere. The sunspots themselves appear to emit corpuscles that induce magnetic storms. At least we blame the sunspots because the magnetic storms tend to occur a couple of days after a large spot has rotated past the center of the solar disk. However, we have to be careful here, since we cannot actually see the corpuscles leaving the spots. A sunspot is only the most visible feature of a much broader disturbance which we simply call an active solar region. It is the fever thermometer which indicates a deep-seated disorder. Refined observations show the presence of flares, active prominences (which I shall describe presently), regions of intense brightness in the immediately overlying corona, and brighter-than-normal patches on the solar surface known as faculae and plages. All these features share in the 11-year sunspot cycle. Whether it is the sunspot

itself that showers us with corpuscles, or some other member of the retinue, remains to be determined, and for the present we should perhaps just attribute the resulting magnetic storms to the active regions.

More mysterious are the periodic magnetic storms that are clearly solar in origin, but seem to have nothing to do with any distinguishable solar feature. They come in series, starting with a small magnetic disturbance. Twenty-seven days later comes a larger disturbance, and others at 27-day intervals. Successive storms build up in intensity and then gradually die out. The whole series will include perhaps a dozen recurrences at 27-day intervals. Yet the most refined observational techniques have revealed nothing on the sun that appears to accompany these storms. The evidence for their solar origin is difficult to avoid, however. The 27-day period is exactly the rotation period of the sun. It appears, therefore, that every time a certain patch on the solar surface rotates into a position facing the earth, we are treated to a shower of corpuscles. Just to have a name, we call such a patch an M-region. If the equality of the solar-rotation period and the recurrence of M-region storms were the only evidence we might put it down to a remarkable coincidence. But this is not all. The frequency of M-region storm sequences unmistakably shares in the sunspot cycle. The odd thing about it is that we have most of these magnetic storms around sunspot minima. It appears that the M-regions on the sun do not get along well with sunspots or active regions. We have specific confirmation of this. If we arbitrarily assume that the M-region is the patch of solar surface that was squarely at the center of the solar disk when the corpuscular shower started on its trip from sun to earth, we find that the M-regions avoid the neighborhoods of sunspots like the plague. Furthermore if a sunspot develops in the M-region, the corresponding series of magnetic storms abruptly ends. So we have learned that an M-region is a portion of the solar surface that appears perfectly normal in every other respect to our definitely limited perceptions. One of our efforts at Sacramento Peak is to sharpen our perception enough to identify the M-regions.

I have mentioned prominences in active regions. Of all the objects of astronomy the solar prominences are to me the most beautiful. In variety and form they resemble the clouds of our own atmosphere, but they are, of course, a very different animal indeed. We see them best at the edge of the sun, where they stand up like scarlet flames above the solar surface in beautiful contrast against the dark sky. Aside from their esthetic appeal, they are fascinating objects from the scientific point of view, largely because they are so hard to understand.

A prominence is a great cloud of hydrogen and helium with small impurities of iron, sodium, magnesium, etc. It is usually between 20,000 and 100,000 miles high, with exceptional specimens that rise to a million miles. The variety and complexity of their structure and motions defy description, although there are a few characteristic patterns that serve to classify them. They are too faint to be seen in an ordinary telescope because the glare of scattered light in our atmosphere next to the edge of the sun is so intense that it drowns out the prominences. Fortunately the prominences resemble radio stations in emitting only light of a specific wavelength, while the scattered light is composed of all wavelengths. Just as we can pick out one radio station by tuning to its wavelength and rejecting all others, we can see the prominences through an appropriate filter tuned to their wavelength. In rejecting the other wavelengths, we reject 99.9 percent of the scattered light, and the prominences become visible. The particular red wavelength we usually use is that emitted by hydrogen atoms, so, strictly speaking, we see only the hydrogen in the prominences.

The most puzzling thing about the prominences is their motion, or sometimes their lack of motion. At first sight you may not be surprised to see a motionless prominence apparently floating above the solar surface. You are used to seeing clouds floating around overhead without feeling impelled to report them to the newspapers. The startling thing about the prominences is that there is no air for them to float in. They appear to stay there with nothing whatever to hold them up against the sun's gravity, which is 27 times stronger than terrestrial gravity. The prominences have every appearance of complete ignorance of gravity, whether they are stationary clouds or rapidly moving streamers. We can measure prominence motions quite accurately, and we can calculate how the material ought to move in the sun's gravitational field. Almost invariably the observed motion has no resemblance whatever to the calculated motion.

For explanation we have two choices. We either sacrifice the universal validity of Newton's law of gravitation, or we assume that there are other forces on the sun that oppose gravitation, and sometimes exactly balance it. The first alternative is extremely repugnant. It would mean that in prominences we have found the only example of matter in the known universe that is not subject to Newton's law that every particle attracts every other particle in the universe. The second alternative seems difficult, but we think we are making progress.

The matter composing prominences is highly ionized. Not just 1 atom out of every 10,000, as in our ionosphere, but more like 99 out of every 100. From where we sit on the earth we may regard this as a

peculiar condition, but if we look at the universe as a whole we realize that it is not peculiar at all. Fully half of the material universe is just as highly ionized. We just do not realize what an odd place we live in, or that it is this oddity that makes life possible. The ionization in prominences greatly changes the character of the forces that can act on them, other than the action of gravity, which is a function only of mass or weight, regardless of ionization. Ionized materials are conductors of electricity, which means that they are subjected to forces in changing electric and magnetic fields. It is this property of conductors that accounts for the power of an electric motor.

Now we know that the sun is a place of very strong magnetic fields. They have perfectly measurable effects on the spectrum by means of which we can determine their strength. The fields are especially strong and active near the sunspots, and it is precisely here that we find the most active prominences. We can say quite definitely that the solar magnetic fields must have a profound effect on the motion of ionized prominence material. The problem now is to determine whether the fields could account for the observed motions. It turns out to be a very complicated problem about which there is still a great deal of lively controversy among astronomers. The general conclusion at present is that solar magnetism almost certainly controls the motion and support of prominences, but the details of how it is done will not be unraveled very soon.

Reprints of the various articles in this Report may be obtained, as long as the supply lasts, on request addressed to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D. C.

Fifty Years of Flying Progress[1]

By Grover Loening

Member, Advisory Board
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[With 13 plates]

Fifty years is, actually, not a very long time in the development of one of humanity's greatest means of transportation, but when we stop to appraise aircraft development in this period, and compare the first machine to fly successfully, the Wright "Kitty Hawk," with our latest supersonic airplanes, we see the most striking progress in speed. A gain of well over 1,200 miles an hour in 50 years would average about 24 miles an hour faster each year. Curiously enough, this is approximately the rate of progress that actually did take place for several years after 1909. The Wright Model B and the original Curtiss with a speed of about 40 miles an hour in 1909 were outclassed in 1910 when Leblanc in a Bleriot raised the record to 68 milees an hour. In 1911 the Nieuport did 82 miles an hour. In 1912 the Deperdussin raised this to 108. And so on through the years. The official records today are, of course, not yet inclusive of the actual speeds made by supersonic aircraft because of the secrecy that is maintained. But this much we can say—that if the ever-increasing speed records of the years continue, by the year 2003 aircraft will be flying at 2,400 miles an hour! While it is true that the present supersonic aircraft are merely research airplanes of very small load capacity, more practical load-carrying airplanes will quickly catch up with the initial record-breaker. For example, when subsonic jet aircraft single-seater fighters of recent British and American development, like the Meteors and the Lockheed Shooting Stars, arrived at the 500-mile-an-hour class, it was not very long before the Comet airliner carrying over 36 passengers was doing the same thing. So it will only be a few years before load-carrying aircraft will be equaling and exceeding the speed of the present supersonic airplanes.

[1] Reprinted, with some revisions, by permission from the Journal of the Franklin Institute, vol. 256, No. 6, December 1953.

SLOWER LANDING SPEED

While speed gain is the outstanding evidence of our great progress in these 50 years, the lack of attainment of low speed for landing is our outstanding failure. The very early Wright airplanes had so much parasite drag resistance, so much area with accompanying skin friction, and yet so light a total weight that they could literally be almost dived at a landing spot and then flared out. So it was possible for landings to be made in very restricted areas with high obstacles. One of the outstanding feats in this category was accomplished when Harry Atwood landed his Wright Model B on the south lawn of the White House in 1912.

Early Wright, Curtiss, and Bleriot exhibition teams flew constantly and with great ease off racetracks and even ball parks throughout those exciting exhibition years (1909 to the beginning of World War I)—when the public was being entertained by aircraft to so great a degree, and when the real business of the industry was chiefly building for exhibition work and racing and only in a minor way for military usage. Of course, the wing loadings of aircraft in those days were around 2 to 4 pounds a square foot for biplanes and 3 to 6 pounds a square foot for monoplanes, and the light loading had much to do with this early small-field landing ability. But we have a great loss in aircraft value as of today in having failed to maintain this ability, and failing to such an alarming extent that 10,000-foot runways are now considered too short. Landing speeds of 200 miles an hour are seriously talked of, and the aircraft engineering fraternity, in too large measure, ignores the heavy burden on practical progress and usage that aircraft development is placing on itself by not realizing that we have failed miserably in advancing the technique of slower landing speeds and shorter-field usage. The Wrights showed a way we seem loath to follow.

To be sure, there has been some development of high-lift devices, a very useful development of wing flaps and air brakes without which even the present fast airplanes would be so hopelessly handicapped that there would not be enough real estate around to take care of them. Also, of course, we have the development of the helicopter of recent years to offset somewhat our failure to extend downward the speed range of fixed-wing aircraft. But the helicopter has the very serious deficiency of being a slow aircraft—very useful to be sure, but by no means the final answer until it can carry loads very much faster.

The economics of air transport show that the requirements for large landing areas cannot possibly be increased with the growth that aircraft usage should have in the coming years. This would impose too great a burden on the operator who pays a landing fee, or on the taxpayer for fields built with Government funds. We must reverse the

trend and endeavor to reduce landing speeds every time we increase flying speeds.

Interestingly enough, one of the later activities of Orville Wright around 1923 to 1925, when he had more or less retired, was to spend a good deal of time testing in his wind tunnel the various series of flaps and high-lift devices, which are now exhibited at the Franklin Institute. The ordinary split flap was patented by Orville Wright in 1924, though very few people realize that he was the inventor of this device. The Guggenheim Aircraft Competition came along in 1929 and was designed to be a great stimulus to the progress of more useful and slower-landing aircraft. At least two very advanced aircraft, the Curtiss Tanager and the Handley-Page, very convincingly demonstrated their short-field abilities on both landing and takeoff, and yet for almost 10 years the aeronautical engineering fraternity took only a slight interest in what these demonstrations had shown. The early development and progress of the Fowler Flap were also delayed and stretched out over many more years than was necessary by this curious blindness in judgment or delay in appreciation by aircraft engineers and their customers of the supreme necessity of doing everything to reduce landing speeds.

VERTICAL FLYING

At the present time it appears that this need in aircraft development is receiving an increasing amount of serious attention, and there are several areas in which activity may result in quite striking development. The term "vertical flying" is at last coming into serious use in technical discussions. Designs for vertical takeoff merely on the basis of jet, rocket, or turboprop thrust being greater than the weight, are actively being worked on. Then, too, there is a field of promise in a configuration using an "induced" high-velocity flow over the wing by a disposition of jet-engine intakes and exhaust to give an artificial flow in the slow-speed regime which would greatly increase the lift, even while standing still, greatly reduce the length of takeoff and the landing speed, and yet be readily converted from "lift flow" to pure "thrust flow" for very-high-speed flying.

It was Henry Ford, Sr., who, when discussing aircraft design almost 30 years ago, criticized aircraft engineering very severely for failing to realize that aircraft would really not attain their full development until their power "was used to land with."

SPEED RANGE BY BETTER WING SECTIONS

During this first era of aviation progress, wing sections have been much improved in the range between high lift and low lift and low drag, but there is still much that could be achieved. Speed range (the

ratio of high speed to landing speed) in the first 10 years of flying development was considered extremely good if it got as high as two-to-one. In the course of the ensuing 20 years, owing to improvement in wing sections and finally in the addition of wing flaps, slots, and other high-lift developments, there finally resulted a raising of the speed range to about six- or seven-to-one. In further developments, our figures are somewhat obscured by having to pass through the sonic range. However, an interesting development of the last few years, which cannot yet be sufficiently appraised, is the Delta wing configuration. The range between low-speed high-lift and high-speed low-drag appears to be materially further extended with this new design.

There are other developmental areas in which the extension of the speed range to higher speeds for usefulness and still lower speeds for practicality, are being worked on.

ASSISTED TAKEOFF, AND SKIS

Only recently have we begun to hark back to one of the original conceptions of the Wrights.

The 1903 Wright plane was launched into the air from a small cart, riding on a rail, with no assist to the takeoff, thus saving the weight of a landing gear and the expense of fixing a smooth field. Later, particularly in the many 1905 flights, the Wrights used a catapult to assist on the takeoffs, and eventually added wheels to their planes. A long and painful development of landing gears followed through the ensuing 40 years, but today, interestingly enough, we are beginning to return to the Wrights' concept of assistance in takeoff with the use of the catapult or rocket "jato." There is even being contemplated the use of jet engines of small sizes to give an assist in takeoff and, in reverse, to give a retarding influence on landing. So we see a determined effort being made in aviation engineering to develop a compromise between the highest possible flying speed for utility and the lowest possible landing speed for practicality.

The importance of high speed in aircraft has been proved. There is nothing more useless than a slow airplane. The slow cruising speed of the helicopter is a serious drawback to the success of this type of air transport and must in some way be overcome if this craft is to be of practical use. The economics of air transport, the efficiency of the military plane, and the practical usefulness of the privately owned plane demand the development of ever higher speeds. And yet, as pointed out, this development is hampered by the takeoff and landing limitations of our present-day planes. A realization of this is dawning on our brilliant aircraft engineers, with the result that more attention is being given to assisted takeoffs and catapults. When we look into this field we find some very surprising conditions.

For example, the Air Force (particularly in the operation of attack and assault planes), requires very short takeoffs and landings. And yet, in spite of the successful development by the Navy of catapult launching and the deck-landing hook and wire-engaging retarding mechanisms, it has only lately occurred to the air force of any nation to adopt these devices on the ground instead of worrying about long, clear runways. If there was ever an argument for a united air force, it is this one. On the other hand, if we had had a united air force, we probably never would have had the carriers with their landing traps and catapult takeoffs.

Now several advanced designers are beginning to think in terms of fast aircraft of much lighter weight (because they carry no landing gear to speak of) that will take off on a field from either a catapult or a powered launching car and will land on simple skis that will have no extensive roll and no need for brakes, which get too hot. Thus we see the 50-year cycle reverse itself and return to the original concept of the Wrights.

WATER-BASED AIRCRAFT

While the familiar concrete runway is accepted with a certain finality by everyone, the history of aviation development raises a question as to its necessity. We have prospects, as indicated above, of developing characteristics in aircraft that will allow the fastest load-carrying plane to land more or less vertically in restricted areas. But in the past few years we have seen the development of the jet engine, by which we have ceased to require the use of a propeller. And this has reopened the entire question of whether we should not use water surfaces for aircraft takeoff. In 1907 the Wrights had the same idea, and in preparation for some flying around Norfolk over a fleet review, which they were then contemplating, they began work on pontoons to carry their plane. One of the difficulties they encountered was the incompatibility of propeller tips and spray. The necessity of having the propellers clear the water has plagued seaplane designers ever since. It is the one item that has caused seaplanes always to be so heavy and ungainly, and to have greater head resistance, and therefore at a disadvantage in comparison to land planes.

With the advent of the jet engine all this has changed, and water-based aircraft have gained certain advantages over land-based aircraft. The jet-engine seaplane does not need any great water clearance for propellers, merely a configuration in which the jet intake is reasonably free of spray. The jet exhaust is no problem at all. As a result, the configuration of a jet-driven water-based airplane can not only be fully as streamlined as a land airplane, but is lighter in weight because of not having to carry the heavy landing gear—so difficult to stow, anyhow, in the thin wings required by high speed. In addition,

the development of retractible flexible skis for water landing is achieving a practicality that is very evident, as they enable seaplanes to alight on and take off from rough water. This was previously difficult to accomplish with rigid alighting gear. Demonstrations of the success of this concept have been given in a most convincing manner by the first public flights of Earl Osborn's Edo ski amphibian, the Convair Sea Dart XF2Y-1, and the All-American ski-equipped land planes.

Lest we get too set in our ways of thinking that airplane usage means land-field usage, let us look back into history for a moment and realize that there were two or three eras in which the speed records of the world could only be won by airplanes that were launched off the water. This was importantly emphasized in the Schneider Cup [2] races, the international events that were held in the late 1920's and early 1930's, in which the speed of land planes was far outclassed by seaplanes because of their ability to take off from and land on the water surface under conditions of loading and distance that no land area would permit of. Very much the same thing exists today. If our wing sections and high-lift devices were still to limit us to a speed range of somewhere around 6 or 7 to 1 between flying speed and landing speed, and if we wished to build the very fastest airplane to win a race from a surface takeoff (not air launching), we should have to design a plane that would land and take off at 300 miles an hour and would achieve 1,800 to 2,000 miles an hour in the air. This admittedly would be a difficult achievement on a land-field, noncatapult takeoff; but, interestingly enough, it would not be difficult for a water-ski seaplane takeoff and landing. The only reason that this concept is not as sure-fire as it would have been 25 years ago is that a plane achieving any such high velocity would probably have a thrust greater than the weight and therefore could take off vertically. But it would still have to land; and the vertical takeoff would be considerably easier on the water and much less dusty for the observers. We can only sum up this aspect of our 50 years of progress by pointing out that there is still much thinking, devising, and developing to be done on the fundamental problem of how we take off from the earth and how we get back to it.

WING STRUCTURES

The configuration of the wing structures of aircraft, from the original Pratt-truss Wright biplane, has gone through quite a cycle of development, befogged by an enormous amount of prejudice, misunderstanding, stubbornness, and lack of sound engineering foresight. In-

[2] This trophy was established in 1913 by Jacques Schneider, of France, as an incentive for high-speed seaplane development.

stead of facing the problem of efficient lift and how it could best be obtained, aviators and constructors, from the very start to well into the 1930's, got themselves wound up in so much argument as to the relative merit of biplanes and monoplanes that it took no less than 40 years to clear up what was very obvious from the beginning. The reason the Wrights went to the biplane was perfectly sound and had to do with the question of bracing, weight limitations, and a good deal of engineering convenience. But with the development of higher speeds and more power, the reason for the biplane vanished. But the biplane did not! And throughout the era from 1918 to over a score of years thereafter, the biplane form of wing structure stubbornly persisted. Finally, however, this gave way to the situation we have today—no biplanes in the air in the world except a few old-time crates towing advertising banners! The author derives a very distinct gratification from this because in 1918 he was convinced of the correctness of the monoplane type, but was almost alone in this country in advocating it. He found the acceptance of the monoplane by the aircraft industry's customers so difficult and so surrounded with prejudice that in 1923 he was forced to make the Loening amphibian a biplane for no other reason than to sell it. The greater lift of the monoplane owing to the lack of interference of one wing with another, the considerably lower head resistance, and the lighter weight, won out in the end over the fancied objections that had been harped upon for so long. The untenable antimonoplane sales talk was that a monoplane was unstable, structurally weak, and too "tricky" in maneuvers. The simplicity of the monoplane structure insured its survival—particularly of the type, referred to above, with a simple strut bracing, which type 20 years later came into very general usage and still is seen in the Cessnas, Cubs, Beavers, and others. Of course, eventually the struts have been superseded by the cantilever monoplane structure that is now so nearly universal. A quotation is given here from a treatise on this subject by the author, "Revival of the Monoplane," written in 1919, which perhaps has a message to give:

Aeroplane designing is merely a series of extraordinary compromises that have to be hit upon with a rare judgment because in general all aeroplane features fight each other—weight needed for strength reduces flying performances, roominess for convenience requires a sacrifice to head resistance, etc., so that the competent engineer must constantly balance these opposing features. If he brings out a triplane, let us say, just for the sake of making it a triplane because other machines are biplanes, without having very clear and logical reasons for doing so, he fails in his true mission. The ideal features that we are looking for in the aeroplane structure itself are (1) light weight—the most important of all—(2) the combination on a machine of stability (meaning ability of the plane to stay where it is put along its course), combined with easy controllability (which means a quick, positive response to all controls)—this is perhaps the hardest feature to develop in a new plane; (3) the desirability of simplicity of construc-

tion, which almost always brings light weight with it, and finally (4) we seek a low head resistance, obviously, so as to get our best performances.

No matter what purpose an aeroplane is designed for, be it a large bomber or a small scout, a waste of weight is little short of criminal in aeroplane design, and complication, it is well known, is usually evidence of bad engineering. In fact, the whole essence of really good engineering is simplicity.

But it took the aircraft industry almost 30 years to learn the above lessons in the configuration of wing structures. And yet such lessons and precepts were exactly what Orville Wright taught.

ENGINE LOCATION

Engine location was, of course, another problem of configuration for aircraft designers, which followed prejudices and fashion a good deal more than sound engineering sense should have allowed in these 50 years. The pusher installations at the beginning were convenient structurally and supposedly more efficient. In the case of the single-propeller direct-drive installations like Curtiss, this was later to be proved wrong, because the efficiency lost by the added resistance of the faster tractor slipstream on the fuselage was regained by added lift on the wings. This had apparently been appreciated much earlier in Europe than in this country, because in the 1907-to-1914 era the development of the tractor fuselage airplane in Europe was far ahead of what we had in this country. It is remarkable that in the case of both Wright and Curtiss we persisted so long in this unsatisfactory pusher type because, of course, of the great danger apparent in many minor accidents resulting in fatalities. The engine often fell out on the crew, owing to the light weight structures that were then needed in order to get into the air at all. Probably one of the reasons for this "pusher" persistence was that for exhibition flying there was great merit in the public's being able to see the aviator completely exposed, sitting on his perch at the leading edge of the wing with no protection from the wind whatever. Even Orville Wright succumbed to the tractor configuration when in 1916 he brought out his Model H enclosed-fuselage tractor type, which Howard Rinehart flew around the country so successfully. In seaplanes, the pusher type quickly succumbed because of the spray thrown into the propeller, and the tractor type was even more advantageous there. Then, of course, as we progressed, we got to multimotored aircraft with the engines at first mounted between the biplane wings (a most inefficient configuration), and then finally with the engines as we see them today mounted integral on the monoplane wing. It is interesting to note that this efficient, correct, and simple type has survived as an element of configuration on aircraft for almost 30 years. In this country, of course, the early Boeing 247-D and the Martin bombers of the early 1930's were the eminently successful forerunners of this later-to-become-universal

twin-engine configuration. Before the arrival at this final type we also went through a trimotor period, notably the ubiquitous Ford trimotor and the Fokker. But this type did not last except for the Ford, which was more widely used and was probably one of the most successful airplanes in history.

STABILITY AND CONTROLS

Fifty years have done much to the airplane's control surface, stability, and tail configuration. Reexamining the early Wright plane from the standpoint of our present-day knowledge, we must first pay tribute to the acrobatic balancing skill necessary in order to keep the airplane flying straight. The "Kitty Hawk" was controllable but completely devoid of any natural stability. This applied also to the early Curtiss planes. And while on the subject of controls and stability, we should make it clear that it was in this area that the Wright invention really counted so effectively.

To begin with, the Wrights, and Spratt who aided them, made a discovery in their early gliding experiments for which ample credit is never given. They were definitely and distinctly the first ones in the art, here or in Europe (and this included Lilienthal and, of course, Langley), who found out and verified by test that the center of pressure on a curved surface moves *backward* when the angle of incidence is decreased. All other experimenters had thought that the center of pressure acted as it did on flat plates and moved forward. The Wrights also verified this in their wind-tunnel experiments, and incidentally Wilbur Wright mentions this in his famous paper before the Western Society of Engineers in 1901. Center of pressure location enters with fundamental importance into the question of stability, because the knowledge of this enabled the Wrights to balance their plane correctly and to arrange their longitudinal up-and-down control to operate properly. Then, of course, the basic Wright invention on which they received their patent was their lateral control of roll. They put into practice the realization that up-and-down control and side-to-side control by rudder were not enough for successful flying, and that a third control was needed to balance laterally in roll.

The Wrights first incorporated lateral control in their airplanes by the well-known lateral twisting or warping of the wings. When they did this, of course, the side that had the greater angle of incidence, and would therefore raise up, would at the same time have a greater drag and therefore would require compensating rudder action. This was where the Wrights combined the directional yaw and the lateral-roll control into one movement, although in later types of other constructors like Curtiss, pilots learned to do this as part of their training. As we progressed into the tractor type with a fuselage, the fuse-

lage gave considerable directional fin area, and the very earliest enclosed-fuselage types like the Nieuport had a very low, small, balanced rudder at the end, so that they still required a great deal of coordinating of the lateral and directional controls. But as our 50 years progress, we find the combined rudder and fin area becoming larger and higher, until finally in the modern airplane of today it is so high that much lateral balance is obtained from the rudder and fin alone, and the necessity for coordination has more or less ceased to exist. We have excellent planes that turn very nicely on ailerons and equally good ones that are corrected laterally on fin and rudder alone. Tail structure has also gone through an ever-lengthening development. The "Kitty Hawk" was very short-tailed. Of course, it had the front elevator, a questionably stable layout, which was in short order replaced by a horizontal tail in the rear with a much greater lever arm. But as we come down through the years we find tails of good aircraft becoming longer and longer, and larger and higher, and as we are about to wonder when this will stop, along comes the Delta plane design and brings us abruptly to a halt. Of course modern wing sections have been developed that have a very much smaller and more stable center-of-pressure movement. And this makes the shorter Delta wing configuration much more feasible. The Delta wing still looks as if it will continue to have large fin and rudder areas with considerable leverage around the center of gravity.

There have been two body configuration developments through these years slightly different from the natural growth of the covered fuselage into the enclosed cabin, and into the large, roomy interior bodies of the airliners of today. One, of course, is the Burnelli and Northrup project of carrying the loads in a very thick wing. In the case of the Northrup, this was carried even further into the "flying wing" type where there was no tail at all. But as the "flying wing" developed, what amounted to tails began to be added to the wing tips, giving lateral and directional control leverage around the center of gravity, introducing the complication of added surfaces and weight of controls and their stresses. Whether for this or other reasons, the tailless airplane has not survived, and not even in the case of the Delta wing can we consider that it has survived because the successful Deltas have such large fin and rudder tails. The other differing configuration is the twin-boom holding tail structures such as in the Fairchild Packet and the new Nord Atlas in France. There is a sound reason for this twin-boom design that has nothing to do with either controls or stability. It is the excellent way in which this configuration allows for a cargo-carrying body with accessible doors very conveniently arranged for loading or parachute load dropping. The excellence of this configuration is all the more accentuated when one

contemplates other cargo types that have a large swept-up fuselage with a very high tail, the strength of the fuselage being tremendously weakened by the cutting out of a large door right in the center where torsional strength is needed. To resist tail flutter and carry the high-tail-twisting loads, a very heavy fuselage framing is needed to make up for the door-hole weakening.

As soon as the wing-warping lateral-control system used by the Wrights and by Bleriot disclosed how it weakened the wing structure and what heavy loads it put on the control system, it gave way to the use, at first, of separate surfaces in between the two wings, like the early Curtiss ailerons and the ailerons that Glenn Martin mounted on his first and very successful tractor airplane. In the first few years of flying development, even the elevators and the rudders were quite widely used in a balanced single-surface form. Then when these gave way to the fixed stabilizer and trailing elevator and to the fixed fin and trailing rudder, it was not long—about 1909—before Moore-Brabizon in England, Farman in France, and several others both in Europe and America obtained their lateral control from hinged flaps cut out of the wing tip. These controls have survived ever since, and had every right to continue to survive as they were eminently correct and practical and were easily modified to have mass or aerodynamic balances so that they could grow to large size and still be workable.

However, as soon as we entered the transsonic and supersonic area of flight, aircraft controls by movable hinged-surface areas became open to a great deal of question. Lateral control had already been toyed with in the form of spoilers that would reduce the lift on one side only. But the problem of control in the supersonic region still remains. It is fairly certain now that control by hinged flap is apt to be superseded by something else.

Although we are principally concerned here with our 50 years of fixed-wing aircraft development, control and stability problems are plaguing helicopter development to a very considerable degree. It may be that helicopters will have to adopt a three-rotor system giving three points of control, like the two wings and the fixed tail of the Wright airplane, and then merely vary the thrust of the rotors against each other to get any combination of control forces around the three axes.

LANDING GEARS

The landing gears of aircraft have gone through a complete cycle in these 50 years. The Wrights started with skids alone, and the classiest new designs of aircraft today again look like skids alone. The story of this metamorphosis is about like this: The Wrights started with skids alone, because their feeble craft could not carry the added weight of wheels, nor had it enough horsepower to overcome the wheel friction,

and the landing on skis was simple and effective and short. Then, as their power grew greater and the Model B developed from the original 12-horsepower to the 30-horsepower class and their power loading went down to 40 pounds a horsepower, wheels were feasible and were merely added to the then-existing skids. Then for many years landing gears of airplanes all over the world, with one outstanding exception, were always a combination of wheels and skids, the theory being that if the wheels failed, the skids would save the works. The one outstanding exception was Bleriot in France who never had any use for skids. In those early days we soon discovered that many a landing resulted in an accident, not because the wheels failed, but because the skids broke, dug into the ground, and turned the airplane over. So some of us here proposed and put into effect the simple 2-wheel and tail-skid landing gear which was first introduced at North Island by the author in 1913 and incorporated with a great saving in weight on several then-existing Army training planes. By placing the wheels reasonably forward, nosing-over tendencies were avoided, skids ceased to break, and this type of landing gear became standard for the next 30 years. Then there started to come into wider usage the presently widely used 3-wheel gear with nose wheel forward and the two main wheels aft of the center of gravity. This "level" type is of course very practical and effective and will continue to last for some time. But meanwhile advances continue, and the next step in landing gears is going to be either a catapult track or a dolly truck for takeoff with the airplane equipped only with skids to land on. To be sure, these skids will wear out after many landings, but so do tires. By doing away with the wheel and the tire we not only shorten the landing, but we do away with complicated braking systems and with the heavy weight of wheels and, what is even more serious, the difficulty of stowing wheels in the thin wings that our higher-speed regimes now demand. Of course there is another advantage—the ski landing gear can take off from water, can land on snow, can land on mud, and if we finally do get to vertical-takeoff aircraft, as we are very likely to soon and in great quantities, the wheel gear will disappear except for small rollers for convenience in handling on the ground. And thus we will get back to the ski-equipped airplane that the Wrights started with 50 years ago.

During the landing-gear development of this era, it is surprising to note how tardy and stubborn and backward most aircraft constructors were in adopting retractible landing-gear configurations to improve their performance. It is safe to say that had it not been for the development of the amphibian, which showed the ease with which landing gears could be retracted, the progress in this area would have been even slower.

POWER-PLANT FORMS

Engines have gone through many stages of development, with many changes in form, until we have finally come to the jet engine—a totally different type. Propellers, which may be considered part of the power plant, have also undergone many alterations. The Wrights' original design was little less than inspired. Even with our present knowledge of propellers—our materials of construction, technical skills, and methods of manufacture—the Wrights' solution of the problem of turning B. t. u.'s of gasoline into effective driving thrust for flying cannot be improved upon. Their approach from the correct standpoint of considering their blades rotating airfoils, and their calculations and method of design are an outstanding tribute to their scientific knowledge and engineering ability. In this field of design they really had very little to go on, except some marine screw-propeller theory, much of which they quickly discarded. While they of course had a power loss between the engine and the propellers, owing to the chain drives and sprockets and extra shaft-bearing frictions, this was all more than made up for by the fact that their two large propellers were given a very high order of efficiency at their flight speed of 30 to 40 miles an hour. This they could never have obtained if there had been only one small direct-drive propeller on their little 12-horsepower engine. Also, the Wrights had the good sense to eliminate torque as an added complication to their stability and control problems by having their propellers turn in opposite directions. As the years passed, however, and the power of engines became ever greater—and the power of controls also increased—torque was not too great a problem other than on takeoff. But from the efficiency standpoint, the value of geared-down, large-diameter propellers is becoming increasingly impressed upon us even today by such advanced planes as the Helioplane of Koppen and Bollinger.

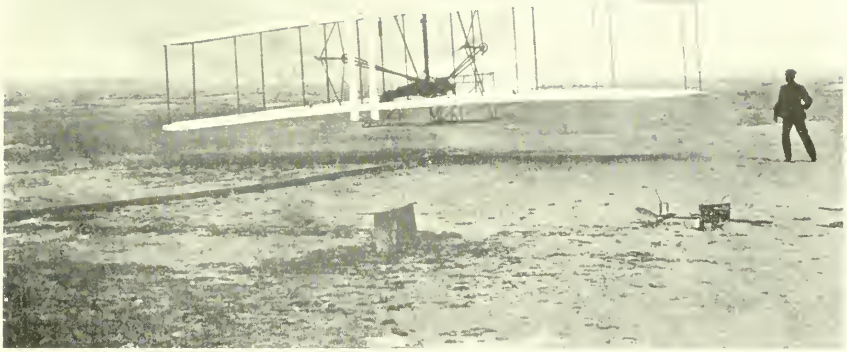
It was years before the efficiency of variable pitch was recognized and adopted in the design of propellers because of the strange unwillingness of aircraft engineers to see the direction progress was taking, even though the signposts were so clear. The propeller construction of the Wrights was of wood with fabric covering to protect the wood from splitting too easily when hit with stones from a field. These wooden propellers were soon found to suffer from humidity and other variables so they were gradually succeeded by metal, first a steel hub with aluminum blades, and then steel blades; and lately there have been some new plastic developments of great interest. The Wrights started out with an engine in a flat pattern. Then they put their four cylinders into an upright model with the crankshaft low. In Europe a start was being made on the first radial air-cooled engine. Next came the tremendously successful Gnome rotary engine, and then,

both in Europe and in America, the large radial air-cooled engine, pioneered in America by Charles L. Lawrance. During development in the use of the water-cooled upright engine, like the Liberty, it became increasingly apparent that whereas the Wrights had good reason for the upright engine in order to have their chain-drive mount on the wing, the later water-cooled tractor types of aircraft should have started out right then and there as inverted engines with the crankshaft high, in order to give maximum propeller clearance for minimum body height.

The problem of radiator cooling was not solved until the advent of the air-cooled engine. The disadvantage of the liquid-cooled engine was especially evident in war planes; one bullet hitting the radiator could wreck the whole mechanism, whereas several cylinders of an air-cooled engine could be damaged without causing the engine to stop at once. Through the years radiators assumed all manner of shapes, sizes, and configurations; they were placed in front of the engine, behind the engine, above the engine, slung underneath, formed into wing surface contours, and so on. The Wrights started out with a simple vertical combination of standpipes that had a large cooling area for the water volume and—a very important item—a large gravity head over the water pump. The weight of the water-cooling system was mitigated somewhat in later years by the use of chemicals for cooling, but the extra plumbing and the extra drag always remained. There were many sighs of relief when air-cooled engines came into use, and an even greater sense of relief now that we have entered into the jet era, with a simple, easy-to-install power plant.

MATERIALS AND CONSTRUCTION

The materials used in construction of aircraft have, of course, varied considerably through the years. At first silver spruce was used by the Wrights and others in wing spars, struts, ribs, etc.; ash was used for the skids as it was a much harder wood. But the generally unsatisfactory nature of wood—the difficulty of getting pieces of the same weight and even of the same strength that could be relied on, and weather changes—all affecting the strength or alignment of the structure, were headaches that quite naturally led, both in Europe and in this country, to the consideration of metal construction. At first this was thought to be too heavy, but it was not long before it was discovered that very thin high-alloy steel tubings gave a weight ratio to their strength that was satisfactory. At first the joints were made with fittings, and later were brazed and soldered; then the Fokker type of welded-tube construction came into wide usage, particularly in the framework of fuselage and tail surfaces. Wing surfaces were covered with oiled silk or rubberized fabric, but both of these materials were



1. The Wright "Kitty Hawk"—30 miles an hour in 1903.



2. The Douglas "Skyrocket"—1,230 miles an hour 50 years later.
(Photograph courtesy of Douglas Aircraft Co., Inc.)



1. The Wright Model A of 1909, with canoe attached for Hudson-Fulton flights over New York harbor. Skid landing gear, no wheels, no rear horizontal tail.



2. The 1909 Curtiss biplane. Engine back of pilot, interplane ailerons, shoulder yoke controls, three-wheel and skid landing gear, and rear elevators.



1. The 1909 Bleriot monoplane. Tractor engine location, warping wings for lateral control, rear elevators and tail.



2. The Curtiss Tanager, winner of the Guggenheim Safe-Aircraft Competition of 1929. Outboard ailerons on lower wings, complete slots and flaps. This plane had by far the best speed range up to that time.



1. The world's-record supermarine seaplane (1929). Necessary propeller clearance and high center of gravity made this a heavy, awkward plane, with greatly added head resistance.



2. Convair Sea Dart. Jet engines and skis accomplish this change from an awkward float seaplane to a sleek supersonic design that suffers no disadvantage from being water-based, and has many advantages.



1. The Loening monoplane of 1918. The first rigid strut-braced wing structure, not widely used until 20 years later.



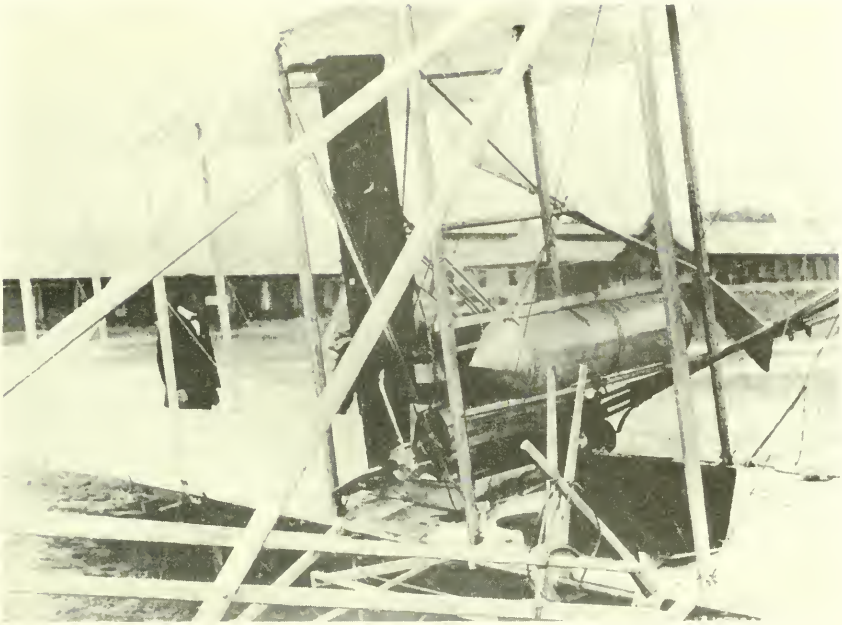
2. The Loening Air Yacht of 1921, Collier Trophy winner. The monoplane structure was strong, simple, and efficient, but not popular enough for acceptance at the time.



1. The Loening OL8 amphibian. This widely used biplane was typical of accepted wing structure in the decade 1920–1930. It weighed 200 pounds more than a monoplane would have, and had a speed of 15 miles an hour less.



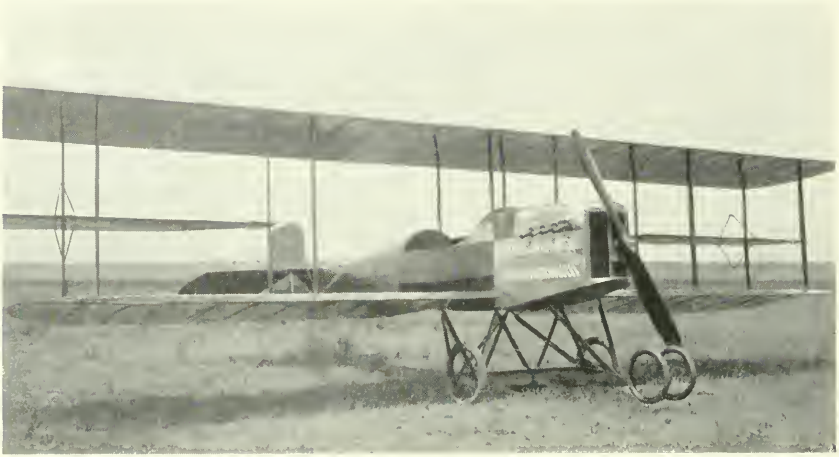
2. The 1909–1912 Curtiss pusher. The engine and radiator were aimed directly at the pilot in case of a crash.



1. The early Wright Model A (1909), with engine to the side of the pilot, and vertica radiator.



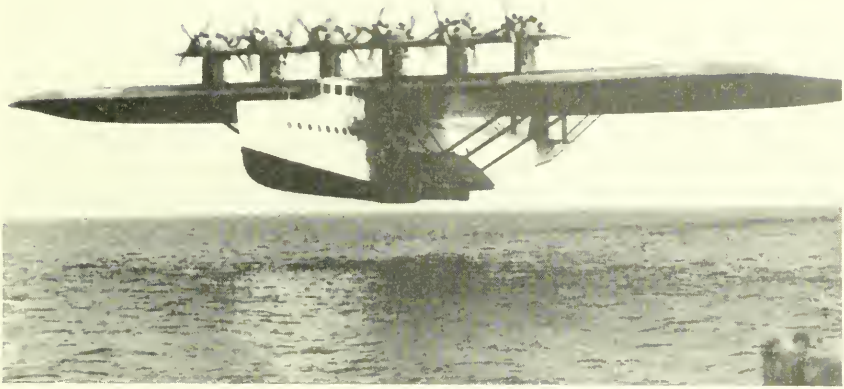
2. An early French innovation that marked the start of an era, the Astra tractor of 1911, with Wright biplane wings on a covered fuselage, and Renault tractor engine and propeller.



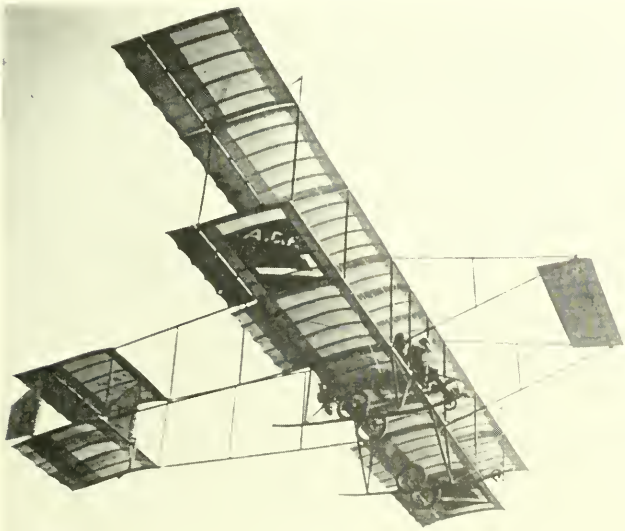
1. America's first highly successful tractor type, the Glenn Martin training plane of 1913. Note useless skids and nose wheels on the landing gear; also ailerons between the wings.



2. The Handley-Page of World War I. This widely used twin-engine plane typifies the configuration of engine between the wings at this early stage.



1. Engine location gone mad. The DOX Dornier 12-engine flying boat of the early 1930's.



2. Farman 1910-1912 pusher biplane showing the trailing-edge ailerons (instead of warping wings), forward and aft elevator. Note also skid landing gear.



1. An early Boeing training plane. Note low rudder, small fin, short tail length, no stabilizer. This was typical of the 1910–1914 era.



2. This 1913 Curtiss tractor had a typical landing gear of skids and wheels. On a hard landing, the skids would break and turn the plane over.



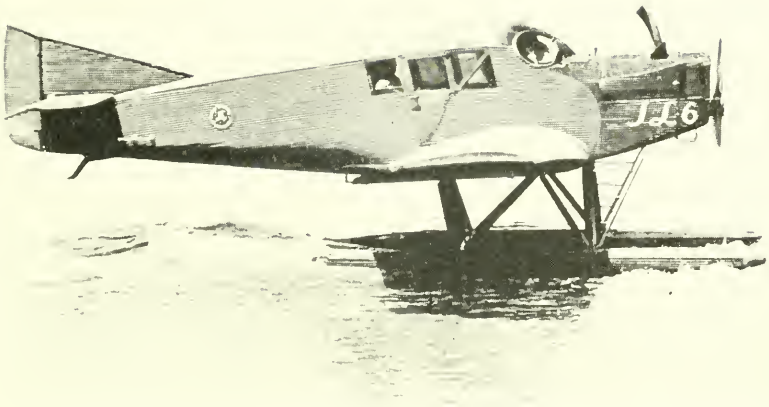
Typical of tail-surface control development are these views of the Boeing B–17 bomber. The upper one shows the original, and the lower one the final model at the end of World War II, 6 years later—a constant increase in the fin area and rudder height.



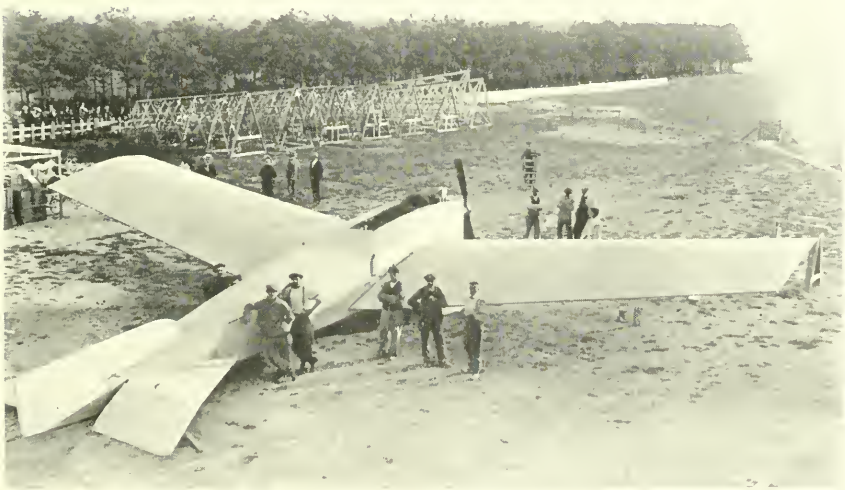
1. The first American simple two-wheel, no-forward-skid landing gear shown here was built by the author in San Diego in late 1913, and was later adopted for all Army aircraft.



2. The practical retractible gear of the amphibian in 1923–1933 led to a much wider adoption of this feature on land planes.



1. The Junkers all-metal aircraft of 1920–1930 was the direct forerunner of present-day plane construction.



2. Forty years ago this highly streamlined cantilever-wing Antoinette was a forerunner of present-day construction, but at the time, the design was ignored.

unsatisfactory as they were subject to tension variations under different weather conditions, so doped linen or cotton was tried. Then plywood entered the field, the beautiful Antoinette monoplane, built in France, being an outstanding example of fine workmanship in the use of this material. Whereas plywood was used for the covering of fuselages, as introduced in the monocoque by Deperdussin in 1912, it was not until toward the end of the First World War that Fokker produced cantilever wings of thick section with wooden beams and plywood covering that took the torsional strains. This was a good deal of an innovation in aircraft structure and pointed unerringly toward the future, but at the time was not adopted very widely.

These wooden cantilever plywood wings were also subject to weathering effects—drying out in the sun, and inability to stand too much moisture—and the strength of the glued joints when subjected to extensive weathering or vibration was questionable. The forerunner of things to come in aircraft structures was the Junkers all-metal cantilever-wing monoplane made in Germany around 1921 and later adopted throughout the world. This was the death knell of the wood-frame, wire-braced box kite of the Wrights and their contemporaries like Farman in Europe. But for a period of almost 20 years the aircraft industry, at the insistence of their customers, continued to build this unsatisfactory type of aircraft, thus delaying the process of developing the Strato-Clipper of 1951 from the Junkers of 1921.

The prejudice against aluminum in structural parts of aircraft was very great in the early 1920's. The aluminum alloy Dural was relatively new, and faith in its characteristic of having the strength of steel for one-third of the weight was slow in taking hold. But gradually it crept into more and more extended use until finally in the vast production era of World War II, all-metal Dural riveted and welded aircraft construction proved itself in the tool room, in the production line, and in combat, so that it eventually became universal. This type of construction is threatened today by the advent of magnesium, still lighter than aluminum and with many other qualities in its favor; by several different kinds of glass and plastic resin materials that have much to recommend them for aircraft structures; and finally by the advent of that great new metal, titanium, which has all the qualities needed, but is too scarce for general use. There is no doubt that alloy metals for aircraft will, from now on, be subjected to great improvements and modifications, which might even include some mutation of crystalline structures by virtue of atomic radiation or isotope application.

It is hoped that in the next two or three decades we may see as great advancement in the development of light metals for aircraft construction as has been achieved in the past 30 years.

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CONCLUSION

Is the development from the Wright "Kitty Hawk" to the airplane of today likely to continue, to bring about as great a change in the airplane of tomorrow? With supersonic flight there is the problem of the generation of heat which will vitally affect the structure of aircraft.

Many scientific developments in the fields of electronics and gyroscopics that have affected our progress in aeronautics will continue to grow in importance. Automatic devices will supplant the human skills now required of aviators, and will reduce the fastest and most difficult flying to such simplicity that a less highly trained operator can handle an airplane as efficiently as the most expert stunt flyer of today. The autopilot and automatic stability machinery can fly a plane far more accurately than even the best human pilot can.

We now recognize two objectives in aviation—the short takeoff and landing at reduced speed and the highest possible flying speed. With the development of vertical rising of aircraft, the need for increasingly large and expensive landing fields is done away with.

One item that has been more or less ignored during the past 50 years, but which has become a serious problem today, is the outrageous noisiness of modern aircraft. The piston-engine airplanes are bad enough, but the present jet configurations are even worse. Unless something can be done to overcome this, the future development of aviation, particularly in the private-vehicle field—will be greatly restricted.

The concept of the Wrights has grown to full stature. It has endowed mankind with a mobility that was undreamed of. To be sure, it has not changed human nature, but it gives promise—by virtue of its very terrible potentialities in war—of forcing the peoples of the world to find peaceful means of getting along together. In the end, the Wrights' hope that this invention might not always be dedicated to war may be realized, and the value of their contribution to man's progress proved by ever-increasing use of aircraft for peacetime pursuits.

Tektites and the Lost Planet

By Ralph Stair

National Bureau of Standards

[With 4 plates]

Tektites, or small glass objects from out of the sky, have long been of great interest to scientists in many fields. Found in great quantities (literally by the million) and in many places over the earth's surface, they have often been overlooked or else casually collected and used for such things as weapon points by the cave dwellers of paleolithic times. In Australia during the early gold-rush days, and in Texas, where they were popularly known as black diamonds (Barnes, 1940), they were widely distributed for use as jewels and ornaments.

These little glass objects, known as australites in Australia, rizalites in the Philippines, bediasites in Texas, moldavites in Bohemia, billitonites in Borneo, and by other names, including Darwin and Libyan Desert glass, usually vary in size from a fraction of an ounce to almost a pound in weight. In shape they range from irregular to such symmetric forms as buttons, spheres, ovals, pears, dumbbells, teardrops, winged bodies, rods, and disks. In color, although the recovered object uually varies from black to a dark shade of green, thin polished sections range from nearly clear through various shades of green to amber or brown. The specimens found in each locality, usually spread over an extended area, as the south half of Australia and a number of adjacent islands in the case of the australites, have common characteristics that indicate original association or common source. Similarly, the chemical and physical resemblances among tektites (Suess, F. E., 1914) found in other localities justify their being grouped into similar subfamilies such as the moldavites of Bohemia.

THE COMPOSITION AND ORIGIN OF TEKTITES

Studies of the compositions and other characteristics of these glasses have revealed many facts that form the basis for interesting deductions regarding their origin. They have a high silica content with the major secondary constituents being the oxides of aluminum, iron, magnesium, calcium, sodium, and potassium (see table 1) and re-

TABLE 1.—*Some tektite glass compositions, specific gravity, and index of refraction data as reported by Virgil E. Barnes (1940)*

Glass	Billitonites 50*	Australites 58	Philippines 44	Indochinites 33	Bediasites 16	Moldavites 11	Darwin glass 1	Libyan glass 65
SiO_2	70. 30	70. 62	71. 20	72. 26	77. 76	80. 73	86. 34	97. 58
Al_2O_3	12. 77	13. 48	13. 52	13. 18	13. 30	9. 61	7. 82	1. 54
Fe_2O_3	. 53	. 85	. 59	----------	. 37	----------	. 63	. 11
FeO	5. 43	4. 44	3. 89	5. 32	3. 36	1. 93	2. 08	. 23
MgO	3. 74	2. 42	2. 23	2. 15	1. 19	1. 59	. 92	tr
CaO	2. 37	3. 09	3. 40	2. 42	. 04	2. 13	. 05	. 38
Na_2O	1. 73	1. 27	1. 59	1. 43	1. 41	. 37	. 15	. 34
K_2O	2. 48	2. 22	1. 84	2. 15	1. 97	3. 60	. 87	None
H_2O	. 08	. 07	. 63	. 20	. 02	. 02	. 46	. 10
TiO_2	. 50	. 90	. 92	. 99	. 76	. 32	. 52	. 21
MnO	. 13	. 42	. 08	. 10	. 01	. 07	nil	tr
Total percent	100. 21	99. 78	99. 99	100. 20	100. 19	100. 37	99. 95	100. 49
Sp. gr	2. 48	2. 454	2. 436	2. 440	2. 357	2. 343	2. 296	2. 208
N_{Na}	1. 527	----------	----------	1. 5133	1. 492	1. 487	1. 474	1. 4624

*Numbers in this line refer to authorities listed in Barnes, 1940, which see for original data.

semble in composition neither any igneous rock structure (Barnes, 1940) of the earth (they differ radically from obsidian) nor that of any glass produced since the beginning of glass manufacture. Although certain sedimentary rocks within the earth's crust approximate their composition it is generally agreed that no natural heat source has existed upon this earth within recent geologic time capable of producing temperatures sufficiently high to fuse this type of glass, since its melting point is nearly 200° C. above that of presently manufactured Pyrex glasses.

These facts, together with the many special shapes encountered, definitely indicate but do not prove a flight through the earth's atmosphere at a velocity sufficient to ablate their surfaces. Although it has been noted that "The meteoric theory of the origin of tektites is certainly one that appeals to the imagination, but in reality there is not a single item of fact that can be adduced in its favor" (Spencer, 1933), the winged types, in particular, present an unchallengeable proof that the glass surface has been heated to the liquid phase and simply blown off the rear of the specimen to form a circular apron at its base. Plate 1, figure 1, shows a fragment of such a tektite picked up in Australia. Many stony meteorites also show a glasslike flow over their surfaces. Hence, tektites must also be travelers from out of space. The big questions are: where did they come from? and how and when and where were they formed?

Ordinary meteorites arrive at the earth's surface in all manner of sizes and shapes. They arrive at various speeds not exceeding about 50 miles per second, and hence must be following elliptical paths (McKinley, 1951) and are a part of our solar system. Their compositions vary in unbroken sequence from that of nickel–iron to stone that is similar to certain types of terrestrial rocks. (No meteorite, however, is anything like a granite or the acidic volcanic rocks.) These and other observations made during the past century support the suggestion made by Boisse in 1850 (see reference) that a study of meteorites should result in an understanding of the earth's structure and composition (Brown and Patterson, 1948), since they possibly came from a former planet having physical and chemical characteristics similar to that of the earth. Today few scientists doubt the hypothesis that meteorites were once a part of a parent planet (or planets) which circulated around the sun in a fashion similar to the observed motions of the remaining planets of our solar system.

Tektites differ from other meteorites in two important ways. First, they are of glass—a very special glass—having a high melting point, a low coefficient of expansion, and a high durability, therefore they differ markedly in composition from other meteoric material. Second, they are found only in small pieces and usually in special shapes.

Let us try to answer the question of their formation first—that is, how and where. Studies of the many meteorites that have landed upon the earth, many of which may be observed in various museums throughout the world, support the hypothesis that they were once a part of a planet. In the development of this parent planet as the cosmic dust collected into a body, heat would gradually develop as the planet's mass increased (Weizsäcker, 1943, 1949). Heating would result not only from the dissipation of potential energy in the contraction process and from radioactivity, supplemented by radiant energy from the sun, but especially from chemical reactions within the planet's body. As a result the planet would become a molten mass with an estimated temperature near 3,000° C. (Klotz, 1949; Brown, 1949) and in which boiling and/or settling processes would result in the concentration of the heavier materials in the planet's core with lighter and lighter material tending to attain chemical and physical equilibrium at higher levels as the various chemical reactions were concluded. Thus the lightest substances, the glasses and glassy silicates, would become concentrated in layers or pools on or near the surface of the planet. If the planet had been small, that is of the order in size of our moon or the planet Mars, the materials composing it would have solidified without appreciable chemical separation (Urey, 1951a, b), as has been the case with those members of the solar system. Hence, to account for the resulting temperatures and separations of the different metal and stony phases (illustrated by the different types of meteorites) a planet approximating the earth in size and general physical and chemical characteristics is required (Brown and Patterson, 1948).

From the above picture we have a planet with a nickel–iron core surrounded with troilite (principally ferrous sulfide) and olivine (a magnesium and iron silicate) and topped with the glassy silicates and glasses. The glasses should be uppermost, that is on or near the surface. As the planet cooled, the surface would solidify first. After the outer crust had been formed volcanic processes similar to those within the earth would be expected to be operative. Indeed meteorites in various museums clearly show that the process by which they were formed was very complex. There was extensive mixing, crushing, melting, segregation and remelting. In fact no theory has yet been proposed that will account for many of the different structures displayed by polished surfaces of meteorites.

No sedimentary rocks, such as shales, limestones, etc., nor structures proving the presence of any type of plant or animal life have ever been observed in any meteorite. That is, no water erosion or organic chemical reactions have left traces within any meteoric material. Although traces of organic acids have been reported in certain carbo-

naceous chondrites, carbon in meteorites is always found to be in the inorganic forms of carbon dioxide, carbon monoxide, graphite, diamond, or as amorphous carbon. If this meteoric planet was originally located between the orbits of Mars and Jupiter, temperature conditions would have been such that any water present would necessarily have been in the solid state (ice). Therefore surface glass formations should have remained somewhat in their original state. The fact that some of the sedimentary material near the earth's surface approximates the tektite glasses in composition may indicate that the surface layer of the earth was once of similar glassy structure which became eroded and transformed into sedimentary rocks.

Tektite glasses, which must have been located somewhere on or near the surface of the meteoric planet, have fusing or melting points and general physical characteristics in the form of striae, strain, and inhomogeneity, which call for a forming temperature between about 1,500 and 2,500° C. It should be noted at this point that glasses of this type are not producible as flash products resulting from a collision or short-period heating by any other means. Long periods of time are required for the different oxides composing the glass to properly fuse and mix into a more or less homogeneous glass product. During this time the temperature must be well above the melting point of the glass. Temperatures too high, on the other hand, would vaporize certain components of the glass. However, the general character of all the tektite glasses indicates incomplete mixing as is to be expected under conditions wherein new materials are being constantly added to the glass batch. The fact that certain of the alkalies remain within the glass is an important consideration in any study of the temperature conditions under which the tektites were formed. The presence of oxygen in combination with the various metals forming the basic structure of the glass serves as conclusive evidence of the existence of that element in considerable amount on the meteoric planet at the time the tektite glasses were formed. Simulated laboratory tests in the making or melting of glasses of similar composition (or, better, with some of the tektite glasses) should result in very useful information regarding the conditions under which they were formed. If the glass were heated to higher and higher temperatures certain of the oxides would be expected to successively boil off leaving glass of such compositions as to make possible a correlation between the glass composition and the temperature conditions under which it was made.

A study of the spectral transmission of thin slices of tektite glass offers a convenient means of obtaining certain information concerning their physical and chemical constitution. Many other avenues of investigation are awaiting exploration. The transmission curves in the ultraviolet, visible, and infrared for some of the tektites are given in

figures 1 to 4. The ultraviolet and visible transmissive properties of a number of australites (fig. 1) and of a group of bediasites (fig. 2)

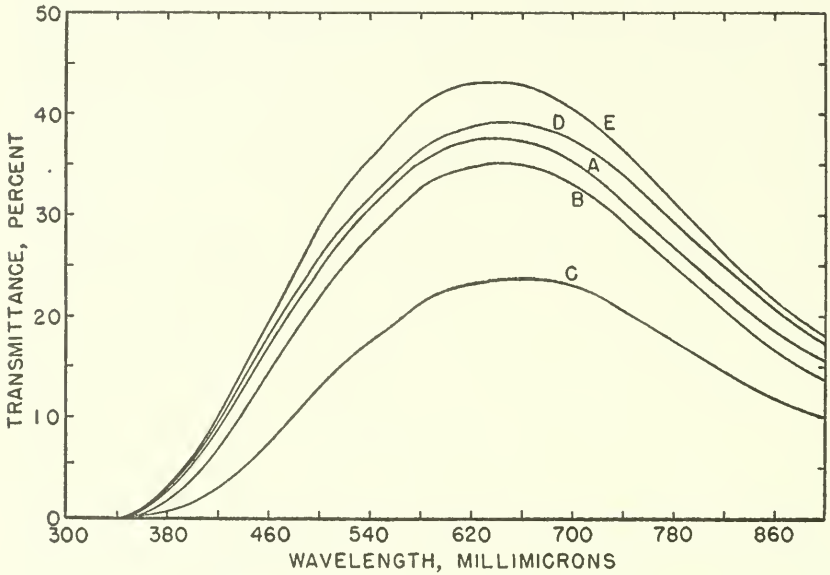


FIGURE 1.—Spectral transmittance of five australites. Sample A from South Australia Museum; others from H. H. Nininger.

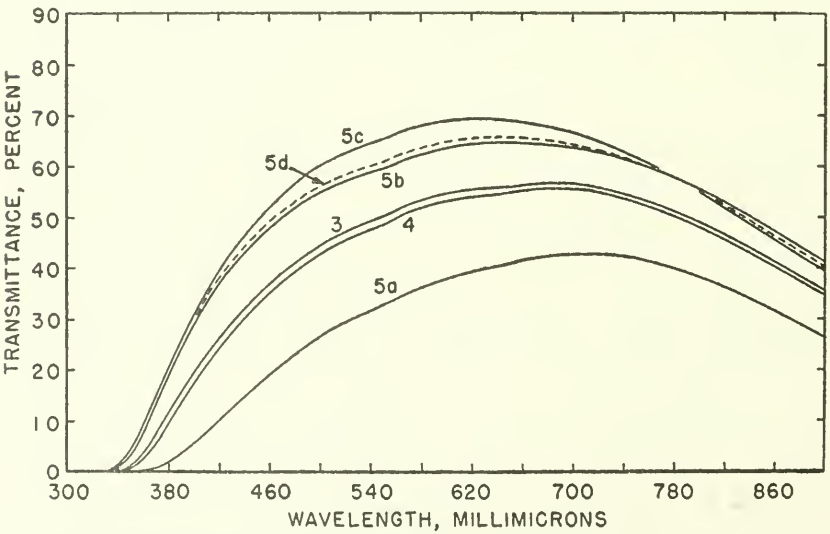


FIGURE 2.—Spectral transmittances of six bediasites from Texas: No. 3, near Muldoun, Fayette County; No. 4, eastern portion of Lee County; Nos. 5a, 5b, 5c, and 5d, near Bedias, Grimes County. Courtesy of Virgil E. Barnes, University of Texas.

illustrate the family character of specimens of this glass picked up at scattered locations in the two cases. The curves of figures 3 and 4 illustrate the types of variations in transmissive properties which may be

expected between samples from different tekite falls. An examination of these transmission data in relation to the values for chemical composition given in table 1 is an example of just one method of scientific investigation into the physical and chemical properties of these glasses.

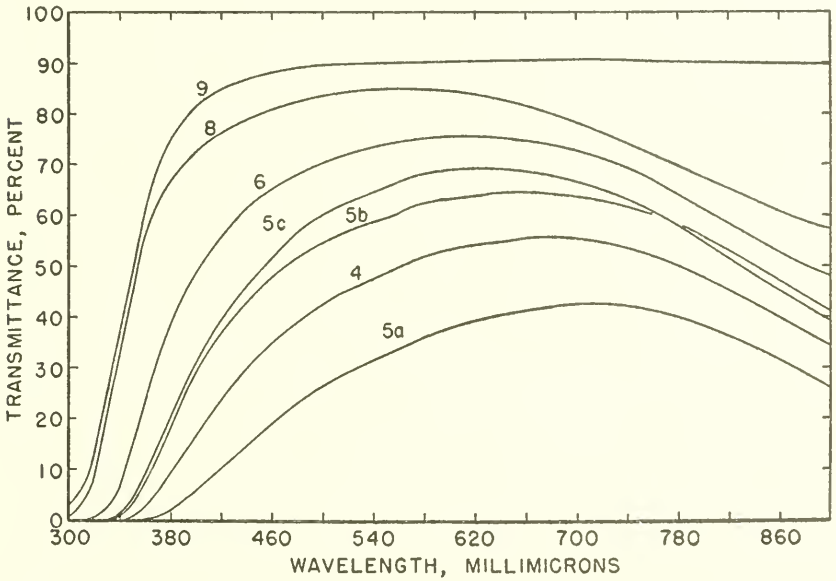


FIGURE 3.—Spectral transmittances of seven tektites from various sources: No. 9, a Libyan Desert glass from Egypt; No. 8, a moldavite from Radoivibix, Bohemia; No. 6, from Empire, Ga.; the others from Texas (see fig. 2).

DISRUPTION OF THE METEORIC PLANET

Now that we have the tektite glasses, as well as the other glassy silicates, together with the other meteoric material located within a planet (or planets) possibly between Mars and Jupiter, what next? That is the $64 question. But the planet, if it existed, did break up for some reason—but how? Not because of an atomic or superbomb made by intelligent beings—there were none. There could have been an atomic explosion, or even a collision with a stray planet from outside our solar system. It is believed, however, that the answer is to be found elsewhere. Suppose, for example, that two similar planets existed within this region of the solar system—two *similar* planets (rather than dissimilar) because all meteorites indicate a formation at the various levels of temperature and pressure that would be expected in a single planet wherein equilibrium conditions were attained (Brown, 1948; Palmer, 1951) at a single high value at the center. These planets would have been acted upon by the giant planet Jupiter in such a way that their individual orbits would have been constantly changed (Kuiper, 1951) relative to each other and to Jupiter. Under

such a situation anything might happen—for example, a collision between them would ultimately result, given enough time. Since the solar system had its beginning some 4,000 million years ago, and since tests on meteorites and tektites, through a study of their helium and argon contents, generally indicate an age for them of less than 100 million years (Martin, 1953; Paneth, 1952; Suess, Hans E., 1952), it appears that at least 3,900 million years were required to produce such a collision. During this time the planets would have made hundreds of millions of revolutions about the sun and thus would have had an opportunity to suffer great orbital changes if only slightly perturbed each time the vicinity of Jupiter was approached.

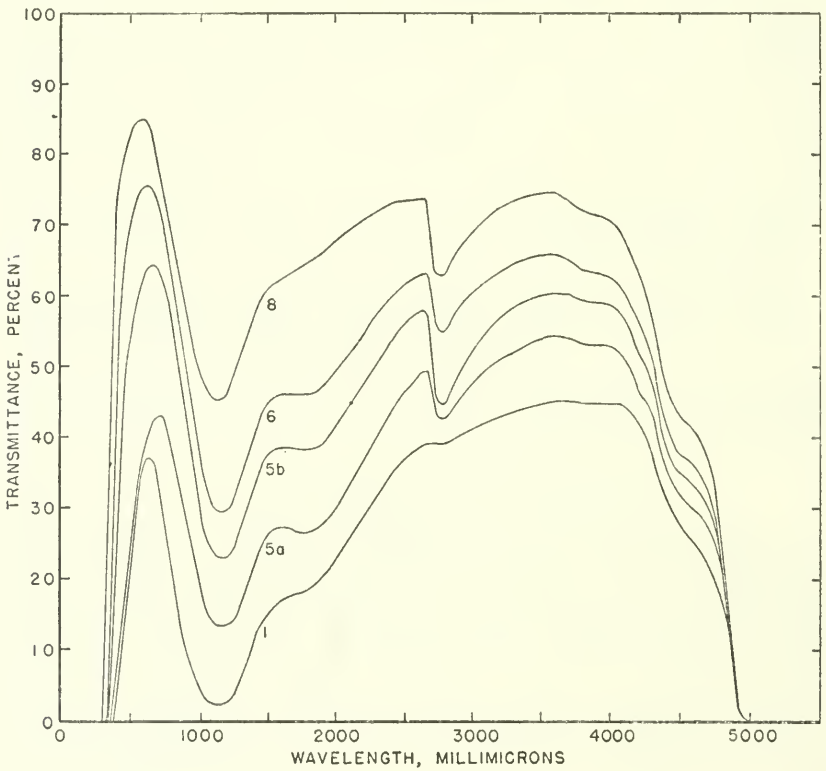


FIGURE 4.—Spectral infrared transmittances of five tektites from various sources: No. 8, a moldavite; No. 6, a Georgia tektite; Nos. 5a and 5b, Texas bediasites; No. 1, a Philippine rizalite.

Or take another possibility, for example. Suppose there was only one planet within this region of the solar system. Again perturbations by Jupiter would constantly change the planet's path through changes in the eccentricity or inclination of its orbit in a manner similar to that in the example for the two planets. Since Jupiter has numerous moons (no doubt originally there were many more than at

present, as indicated by the retrograde direction of the outer ones), a collision with one of them would have been a reasonable possibility, especially since they are distributed over distances many millions of miles from the parent planet. Thus in possibly one of these ways we could have the meteoric planet smashed and its pieces sent flying off at various speeds in all directions. Some of the material would be expected to become diverted into hyperbolic paths and to leave our solar system forever. Other fragments, together with possible moons originally associated with the lost planet, would continue to circle the sun as meteors, comets, and asteroids in orbits of various sizes, eccentricities, and inclinations. Those portions of the planet that were thrown into orbits extending to great distances from the sun might be expected to collect quantities of various frozen gaseous materials such as carbon, nitrogen, ammonia, carbon monoxide, and carbon dioxide. Those fragments that were significantly crushed, or even shattered, and more or less held together by their mutual gravitational attraction, might be expected to collect large amounts of the frozen gases and thus be welded into a solid mass which, when it returned to the vicinity of the sun, would become a brilliant comet. If sufficient amount of the frozen gaseous material were volatilized during the passage by the sun, the solid portions of the comet might fall apart if originally shattered. Such seems to have been the case with a number of comets, in particular the brilliant comet of 1882 which left the region of the sun as four smaller comets.

From time to time chunks of the shattered planet would be expected to (and do) collide with the earth, the moon, and, presumably, with the other planets and satellites of our solar system. The present orbits of the meteors, the comets, and the asteroids cannot be expected to give any reasonable indication of the original path of the parent planet. Although all the components may be assumed to have been at a single location within the solar system at the time of the collision, perturbations by Jupiter and the other bodies of the solar system have changed and rechanged their orbits so many times that about the only safe assumption to be made is that the original planet (or planets) was in an orbit of some shape between Mars and Jupiter.

Meteor Crater in Arizona is a good example of what happens when a meteor (or comet) composed of chunks of nickel-iron collides with the earth. The craters on the moon, visible through a small telescope, are a pictorial record of such collisions (Baldwin, 1949) through the ages on that body. Not all the craters on the moon, however, should be credited to collision with fragments of the lost planet which is responsible for the meteors, comets, and part or all the asteroids now a part of our solar family. Since the age tests on meteorites and tektites indicate that these objects have been subjected to the cosmic-

ray intensity in our part of the Milky Way (our galaxy) for a period not exceeding about 100 million years as indicated above, then only the newer craters—in general the smaller ones—could have been produced by this material. It is suggested that the larger lunar craters, which, incidentally, were made during the period when the moon was still partly or mostly liquid—that is, during the early history of its formation nearly 4,000 million years ago—must have been made by the impact of large objects from some other source. A possible and logical source of such objects could have been a family of small moons once circulating around our earth. Such a hypothesis seems reasonable from a number of points of view. Such small moons were not only possible, but many were actually formed in the condensation of the cosmic dust within our solar system. For example, one of the moons of Mars is barely 5 miles in diameter. Other moons are quite small. We do not know how many small ones may be circling some of the outer planets. There is ample reason to think Jupiter may have lost a number of her moons as indicated above, because capture by the sun, or collisions, would be more probable in the case of the nonretrograde traveling ones. On the other hand, if there should be capture of moons, by Jupiter, from the material scattered in a planetary collision in the region between Mars and Jupiter, a retrograde direction of revolution would be expected to be the more probable. In the case of the earth's possible original system of moons, the capture of the smaller ones by our present satellite would account nicely for its giant size relative to that of the earth as compared with the sizes of other moons relative to their parent planets. Furthermore, little evidence exists to indicate that the earth suffered the extensive bombardment with large objects as was the case with the moon, at least during the last 100 million years since the time the meteoric planet ended up in some sort of major catastrophe. However, since at that time the moon was apparently in a semiliquid state, the earth was probably still intensely hot so that any collisions with it would simply result in the addition of material which would be integrated throughout the earth's structure. Hence, the old and very large craters on the moon (the seas) might indicate the accumulation of a vast number of planetoids (Urey, 1951a, b) by the earth in its early history. If such were the case (and it is highly possible and even probable), and since these could not have come from the lost planet as indicated above, their source must have been from an early group of captured moons (by the sun) from Jupiter and the other planets, or else from a multitude of small planetoids once a part of our solar system and which might have been distributed with all sorts of orbital eccentricities more or less throughout its limits.

FLIGHT OF THE TEKTITES

Now, how do we get the millions of small glass tektites from the debris of the lost meteoric planet? Why not a few large chunks of glass? Well, glass is a fragile article, especially when not well annealed. It readily breaks upon mechanical or thermal shock. Take, for example, a chunk of such material traveling at 40 to 50 miles per second, the usual speed of many meteors. When it hits the earth's atmosphere an immense amount of heat is developed at its surface. The glass suffers both a terrific thermal and mechanical shock. What happens? It necessarily flies apart and is scattered in many small pieces (Hubbard, Krumrine, and Stair, MS.) over a wide area, usually elliptical in shape. The sizes of the many small pieces depend upon the coefficient of expansion, the degree of annealing, and other physical properties of the material. Indeed, tektites having variations in composition are found to vary in size in general accordance with their physical characteristics. For example, Libyan Desert glass may be found in pieces up to 10 pounds, while a moldavite, having an intermediate coefficient of expansion, may weigh up to a pound or two, but a tektite of relatively high temperature coefficient of expansion, for example an australite or rizalite, is found only in very small pieces usually weighing not more than an ounce or two.

A study of other physical characteristics of the various tektites recovered also supports the above deductions. Striae, strain patterns, and inhomogeneities indicate that the small pieces were once a part of a larger body, since there is a lack of any appreciable distortions near the surfaces. Plates 3 and 4 show this characteristic of a number of the tektites. This rules out the formation of these glass specimens by a fusion of meteoric material while passing near the sun in their orbit before landing on the earth. The time of flight through the earth's atmosphere is too short for the conduction of sufficient heat to melt or soften the specimen deeper than a surface film which, for the greater part, is swept away as it is formed. Only in the case of some of the australites (whose prehistoric fall was geologically recent) does any evidence remain to show the two distinct phases (Fenner, 1949) in the formation of the glass specimen: the central core of glass whose structure indicates a more or less annealed condition indicating that the glass cooled slowly, and an outer surface having high strain and other characteristics indicative of having undergone softening at a later stage. All traces of double melting of all the other tektites, which fell during various earlier ages, have long since been eroded away. As noted above, and shown in plate 1, figure 1, an apron is often left on australite specimens that apparently did not rotate while in flight. Those that rotate may be expected to assume one of the natural forms such as spheres, ovals, buttons, dumbbells, or the

like, as the rough edges are smoothened in flight. Additional sculpturing effects, such as smooth lines and grooves, result from the removal of glass in an uneven manner, presumably in part by the particular aerodynamical forces brought into play with the object traveling at such a high velocity, assisted by a more rapid melting of the softer striae within the glass, but later modified greatly by weathering and chemical reactions and resulting in the removal of quantities of glass where the more solvent material or other inhomogeneities occurred. Plates 1, figure 2, and 2, figure 1, illustrate beautifully the character of some of these surface features. Some of them are wormlike grooves and navels, often completely interlacing the surface of the specimen. This feature is more pronounced in some of the billitonites (pl. 1, fig. 2) which have probably been buried in moist soil for a long time. When examined under low-power magnification (about 10) numerous fine surface lines and figures, probably corresponding with the internal striae (see pls. 3 and 4) of the specimen, may be observed both on the outer surface and within the pittings.

It has been noted that the tektite glasses do not contain inclusions of other materials such as are found in many ordinary types of meteorites. Suppose inclusions did occur within the glass. Such material, if of fine structure, would have been completely melted and have become a part of the glass body. If not of fine structure, it would probably have had a temperature coefficient of expansion so much different from that of the glass that when the slab of glass containing the foreign material hit the atmosphere rupture would occur along the dividing surfaces. Furthermore, greater shattering would probably result so that the smaller pieces of material would probably either be completely disintegrated in flight or else land with all surfaces originally containing the two kinds of material being completely obliterated. Glass meteorites, composed of softer glasses, which would have a lower content of silica and higher amounts of potassium or some of the other oxides having high coefficients of thermal expansion, would be expected to shatter into much smaller fragments and then to be completely fused, possibly vaporized, before landing. Hence, recovery of any soft, low-melting type tektite glasses would at best be rather improbable.

It has been suggested by Nininger (1952) that the tektites are glassy material splashed from the moon during the course of a meteoric collision (and the resulting explosion). The splashing of the moon material cannot be denied, and some of it no doubt eventually reaches the earth, but it is thought that its composition, while glassy (Stair and Johnston, 1953), could not possibly correspond to the near-perfect glass of tektites because of the lower temperatures under which the moon was formed. Nor could glass of this type result in a flash reaction for the reasons noted previously.

TEKTITES, A KEY TO COSMOLOGICAL PROBLEMS

Scientific study of the tektite glasses has been somewhat neglected in meteoric investigations, principally because it was only recently that their true origin had been established. It was long contended that, as the glass tektites were so far removed from other meteorites in composition, they could not be of the same origin. However, since their durability greatly exceeds that of the softer glasses and their geological associations indicate that they have landed on the earth in showers during the past 50 million years (neither tektites nor other meteorites have been found in any of the ancient geological formations), it appears reasonable to assume that only the more durable types of glass could have survived the weathering of the ages. On the basis of such an assumption, it would be possible for all types of glassy meteorites, from the tektites to ordinary stony ones containing only traces of glass, to exist. It might also have a bearing upon the abundance of tektite material relative to that of other meteorites, which, within certain areas, exceeds in tonnage that of all other types combined.

The complicated structure of tektite glasses still holds many of the secrets relating to their formation in the parent lost planet. The study of their physical and chemical characteristics together with research in the production of similar glasses should, therefore, furnish valuable information and thus become the key (the Rosetta stone) to the solution of some of the cosmological problems facing the astronomers, geologists, and meteoriticists today by adding not only to our knowledge of the origin of these glassy meteorites but to better understanding of the formation of the solar system—even of the universe itself.

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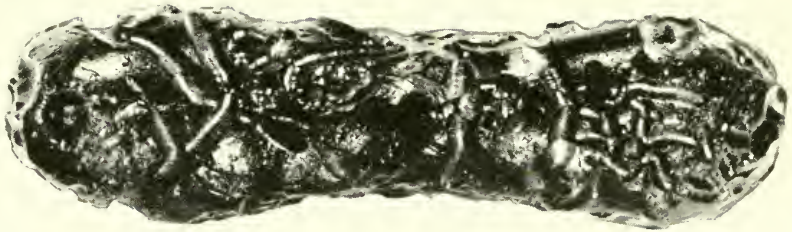
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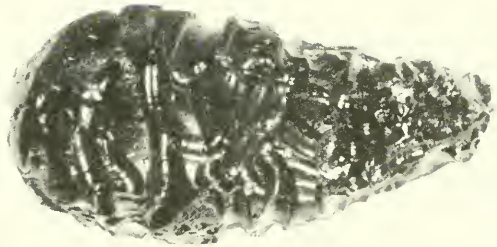
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1. Fragment of australite, illustrating a winged tektite having an apron resulting from partial fusion in flight.
(Photograph courtesy of Wm. J. Cassidy, South Australia Museum.





2. Billitonites from the island of Billiton, illustrating the wormlike grooves and navels resulting principally from chemical corrosion through being buried in moist soil for many years.
(Photograph courtesy of E. P. Henderson, U. S. National Museum.

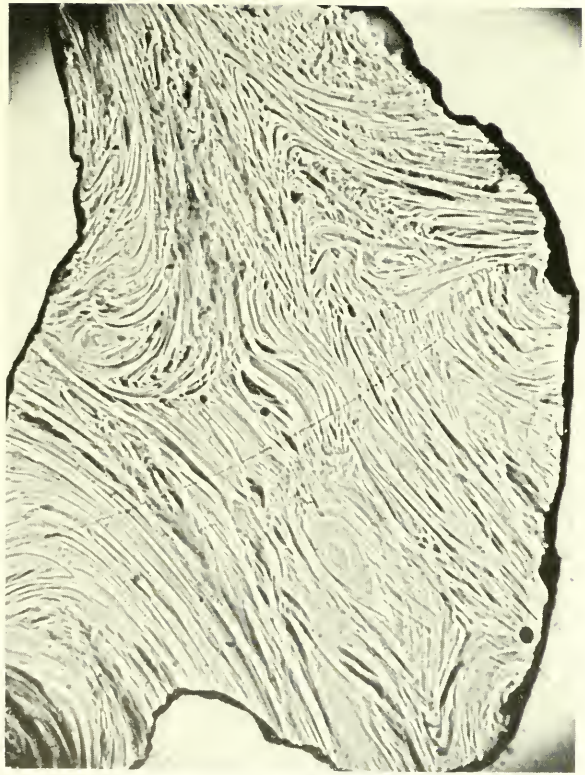


1. Tektite from Paracale Bay, Philippines, illustrating surface features often found on tektites recovered within that area.

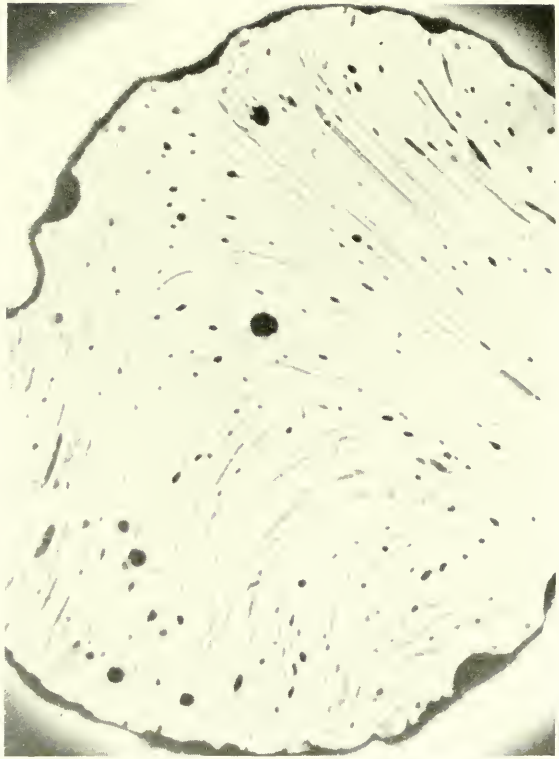


2. American tektites. Smaller specimen from near Delhi, Beckham County, Okla.; larger specimen from Empire, Ga.

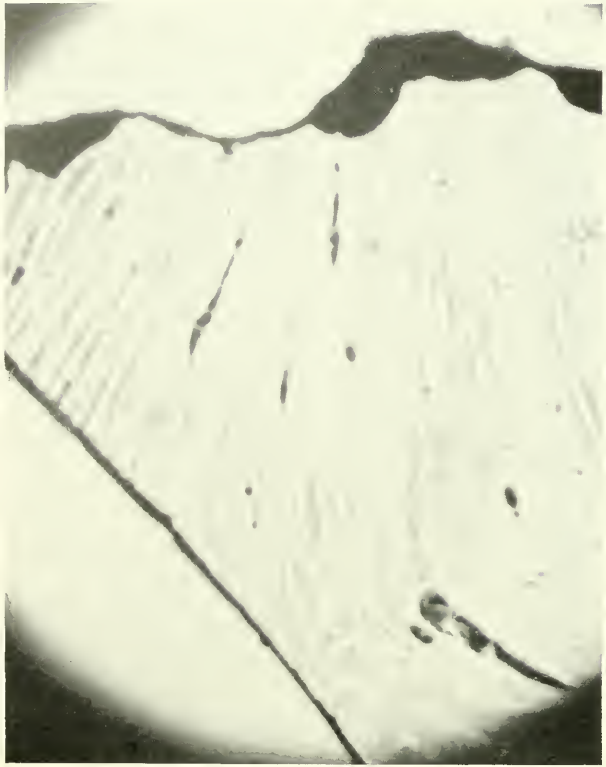
(Photographs courtesy of E. P. Henderson, U. S. National Museum.)



1. Moldavite, illustrating the inhomogeneity of a thin polished section by means of transmitted light.



2. Rizalite, illustrating the presence of bubbles and marked inhomogeneity by means of transmitted light.



1. Georgia tektite, illustrating the inhomogeneity of a thin polished section by means of transmitted light



2. Libyan Desert glass, showing internal structure of a thin polished section by means of transmitted light.

On Comparing the Brain with Machines[1]

By D. M. MacKay

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In discussing this subject, three questions must be distinguished: How far does the brain resemble existing mechanisms, such as electronic computing machines? How far would it be possible to imitate human behavior with a suitably designed artificial mechanism, or "artifact"? How far is it possible to envisage a model that would imitate human behavior, and also work internally on the same principles as the brain?

Only the third question is here discussed in detail. The first is of trivial interest. The second may be answered by saying that as soon as the required behavior has been specified by an adequate statistical test, a simple logical process can convert the test into a description of at least one possible mechanism that will meet it. The chief difficulty lies not in meeting the test, but in knowing enough to frame it. It is only here that philosophical issues arise; these will not be discussed in this article.

The brain is unique in offering two kinds of clues as to its function: through physical experimentation and through psychological study. The language of information and control belongs to both fields, and a theoretical model is best designed in these terms. The first step in its construction is to summarize the conditions that it must meet according to present knowledge; these are regrettably broad. Next, a model meeting these conditions must be invented, and its theoretical characteristics checked against observation of the brain in action. Any discrepancies should yield information toward refining or replacing the model, and so the cycle continues.

Progress was at first represented more by elimination of invalid models than by the development of a valid one; but the lines on which a valid model may be sought are becoming gradually clearer. It is

[1] This article is based on a discussion by the author before Sections J, A, and I of the British Association for the Advancement of Science, September 8, 1953. Copyrighted, 1954, by the Society of the Sigma Xi and reprinted from the American Scientist, vol. 42, No. 2, April 1954, by permission of the copyright owner.

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suggested that a probabilistic model, capable of altering its statistical rules of activity according to experience, offers good prospects of success as a research tool.

A good model is judged not only by its predictive power, but by the clarity with which its failures offer constructive interpretations. Understanding is to be distinguished from ability to predict. Even a complete mathematical equation for the nervous system would contribute little to the understanding we require, and the useful role of conventional mathematics is likely to be small.

Perhaps the major aim of this work is to provide a working bridge between the languages of psychiatry and physiology, for the better coordination of attacks on mental disease.

Such studies are sometimes attacked as "debunking man." This appears to be a misconception. I shall suggest (*a*) that ethical responsibility in no way hangs on physical indeterminacy in the brain, and (*b*) that physical description and mental description reveal complementary aspects of one and the same human activity, which in its full nature combines and transcends both.

COMPARING THE BRAIN WITH MACHINES

When we speak of comparing the brain with machines we may mean one of three things, according to which one of three quite different questions we may have in mind.

We may want to know to what extent the brain resembles existing mechanisms, such as electronic computing machines. The short answer to this question is that electronic computers are not designed to resemble the brain: in fact they are explicitly designed not to resemble the brain in most of its important functions. A computer that developed esthetic preferences and had occasional ideas of its own would have a limited field of usefulness—or at least an unusual one! Any resemblances there may be are for our present purpose trivial.

The second question we might have in mind is whether an artificial mechanism, or "artifact," could ever be designed to imitate all human behavior. Could such an artifact frame novel hypotheses or write sonnets, for example?

This question is slightly more interesting from some points of view. By imitation, of course, we should mean much more than the sort of imitation provided by a phonograph or even a walking, talking robot. In fact, we are entitled to demand that the artifact would have to meet every functional test which the brain—or the nervous system as a whole—can meet.

But the answer to this question also is fairly straightforward. Any test that we can specify exactly, or even statistically, in terms of the behavior to be expected in given circumstances, can in principle be met by an artifact built only of mechanisms that are now available to us.

The reason is that by a simple logical process we can turn any such precise test into a description of at least one mechanism that will meet it. It may be an inordinately bulky mechanism, but we shall be unable to distinguish its performance from the behavior that has been specified.

It follows that all arguments that begin: "You'll never get a machine to do such-and-such," are foredoomed as soon as the speaker has been induced to say precisely what behavior he would regard as satisfactory. What is doubtful, of course, is whether we shall ever be clever enough to specify, even in principle, an exhaustive test for humanlike behavior. It is this aspect of the problem, rather than the mechanical difficulty, that I believe is of more than trivial philosophical interest (Wisdom et al., 1952).

The third question I have raised is actually the one of greatest practical importance: How far is it possible to envisage an artificial mechanism that would not only imitate human behavior, but work internally on the same principles as the brain? It is this possibility that I want chiefly to discuss. How do we set about comparing the brain with machines in this sense? How far have we progressed, how far can we hope to go—and what is the point of it all anyway?

METHODS OF APPROACH

The brain is unique in offering two kinds of clues as to its function, in physical observation on the one hand and psychological study on the other. Each of these methods requires a very different language, and the problem is to find a common language in which to associate the two. Fortunately, the language of information and control theory turns out to be just what is needed, since it belongs in a sense to both fields.

The first step, therefore, in designing a theoretical model must be to sum up what we know of the way in which the brain handles information, at all levels from the nerve cell up to the complete organism. This provides less positive guidance than one might think, but it does set certain negative limits on the kind of model we may envisage (see, for example, Grey-Walter, 1953).

We next ask: Within these limits, what mechanisms are there that could handle and respond to information in the same way? Again we can tackle this question at various levels. The exponents of what is called "nerve-net theory" start with an idealized model of the nerve cell, and develop from it theoretical networks capable of complex functions.[2] My own preference is for a statistical model of the whole system, with a flexible structure that may be brought gradually to resemble the large-scale structure of the nervous, and humoral, system (MacKay, 1952).

[2] Most of this work has appeared in Bull. Math. Biophys. from 1943 to date.

Now, of course, even in our present state of ignorance, a fair number of models might be designed to meet these conditions, although an increasing number are being ruled out. So the next step must be to study in detail how such a model would work, and how it would go wrong; then to go back to the brain to discover whether it does likewise. The discrepancies we find can, if we are lucky, suggest the lines along which we should refine or redefine our model for the next comparison.

Let me give you an example. No one knows how the visual system enables us to recognize the shape of an object irrespective of its size. One hypothesis suggested a model in which the visual map in the cortex was rhythmically magnified and diminished in size about ten times per second, in step with the electrical rhythm of the same frequency which can sometimes be detected at the back of the head.

There are, of course, anatomical and other tests of this type of model, and I do not think that it meets them very satisfactorily; but one way of testing such a model would be to ask: Is there any way in which the mechanism could be tricked? If so, can we trick the brain in the same way?

One obvious trick might be to present the model with a pattern whose size was fluctuating at the same rate as its internal magnifier. In the simplest form of model this could either prevent the pattern from being recognized, or at least give rise to perceptual anomalies. It is not difficult to try this experiment on a human subject. A television tube can draw a square or triangle whose size fluctuates at the same rate as the electrical potential on the subject's scalp. But in several such tests I have never found any evidence of anomalous perception (MacKay, 1953).

A null result of this sort does not, of course, prove that rhythmic "scanning" does *not* occur. It proves only that the hypothetical model of the process was wrong in at least one respect. I think there are other grounds for believing that scanning, in the engineer's sense, is unlikely to occur, but that is another story.

PROGRESS AND PROSPECTS

From the example just given, you may get the impression that our model making is still at a very rudimentary stage; you will be correct. There are still far too many possible models that cannot yet be ruled out on the evidence at hand.[3] Some, like the digital-computer model, will fall gradually by the wayside as other models are evolved which beg fewer questions. The choice of a model is much more a matter of intuitive judgment than of strict deduction.

[3] Readers may consult the eight pages of references given by F. L. Stumpers in "A Bibliography of Information Theory," Massachusetts Inst. Techn. Rep., Feb. 2, 1953.

Among the less explicit, though nonetheless important, restrictions on modelmaking is the requirement that the brain as modeled must have been capable of growing that way. This has led some of us to investigate the possibilities of self-organizing statistical, or "probabilistic," models. By a statistical model may be meant (*a*) one whose elements function deterministically but whose detailed interconnections are assumed to form more or less randomly (Ashby, 1952), or (*b*) one whose elements function indeterministically, to some controllable extent (MacKay, 1952).

The model that promises to be most useful is statistical in both these senses (Wisdom et al., 1952; MacKay, 1952). Its basic feature is the ability to adjust the rules of its own activity according to the degree of success it attains; but it does this, not by throwing switches, but by adjusting the relative probabilities of different patterns of activity. Its rules, in other words, are grown statistically as a result of its own trials and errors. The interconnections between elements are not hard and fast, but each link has an adjustable probability of functioning, which will in general depend on the location and the timing of all neighboring activity.

You might picture a typical element in such a model as something like a gun with a rather uncertain trigger. The farther the trigger is pulled, the greater the probability that the gun will go off. If we suppose that when a gun goes off, its firing alters the tension in the trigger of another gun, without necessarily firing it, we have the basic model of a mechanism that can alter the probabilities of its own activities.

I wish it were possible to go into more detail. But perhaps you can see roughly how a network of such elements, if supplied automatically with signals to indicate success or failure, could use them to alter probabilities so as to grope its way more and more quickly into a pattern of activity to "match" any incoming patterns that persisted in recurring. Its good guesses, so to speak, could be made to persist, and its bad ones to drop out. But because its activity would never be uniquely determined by the input, there would always be room for occasional spontaneous attempts to try something new as a "matching response" to the flux of events. With a hierarchical structure, these attempts could include guesses about the relative probabilities of other guesses, so that abstractions of any order could be evolved (Wisdom et al., 1952).

Such a model is sufficiently general to be capable of any activity we may care to specify, and it bears promising resemblances to the human nervous-and-humoral system. But if it is fortunate enough to survive the next 20 years, our only reasonable certainty is that the model will have grown almost out of recognition. If it has not, it will have been of small service.

This brings us to the third question: What do we hope to achieve by all this?

THE FUNCTION OF THEORETICAL MODELS

A theoretical model of the type we have been discussing is intended to serve as a tool of research. We can think of it as a kind of adjustable template which we construct on some hypothetical principles, and then hold up against the real thing in order that the discrepancies between the two may yield fresh information.

This in turn should enable us to modify the template in some respect, after which a fresh comparison may yield further information, and so on. The model, as it were, "subtracts out" at each stage what we think we understand, so that what is not yet understood is revealed more clearly.

You will see at once that we shall judge a good model for this purpose not so much by the success with which it imitates or predicts, but rather by the clarity with which its failures enable us to infer what to modify next. To be sure, our aim is to approximate more and more to the real thing. But we may easily be misled into an approximation process that doesn't converge. It may even pay us to discard one model for another which offers us fewer numerical predictions to start with, if the first model shows signs of requiring one or more additional hypotheses for each phenomenon it encounters! It is worth remembering, in these days when predictive ability is so often confused with understanding, that the epicyclic "theory" of planetary motion would have been less at a loss to account predictively for the anomalous motion of Mercury than Kepler's theory which displaced it!

Our second criterion of a good research model is that it should not only function normally like the brain, but also that it should go wrong in the same ways. As we have seen, our model is tested most severely, and is of greatest potential value, in the study of cerebral disorders rather than of normal function—difficult though it is to draw the line between the two areas.

It is possible that some mathematicians may feel that no theory is worthy of the name until it has produced some equations. But I want (if I dare) to emphasize that what we wish to understand in such multidimensional problems would be very little illuminated even if we could produce a gigantic equation relating all the variables that we should never measure.

Understanding, here as always, means knowing as far as possible what to expect in given circumstances, and what to infer when the expected doesn't happen. The difficulty is that the data, on which we want to organize our expectations by means of our theory, are mostly not measurable variables but qualitative abstractions from function. So it is only a small part of our aim to develop equations

leading to numerical predictions. This satisfaction we must cheerfully leave to folk with a different type of problem.

But behind this approach to the study of the brain there lies a more general motive. It is the hope of providing a working link between the concepts of psychiatry and those of physiology and anatomy. Cooperation at present between those fields is hampered by the sheer difficulty of imagining physiological correlates of some psychiatric terms and vice versa.

Now the language of information and control lies, in a sense, between the languages of psychiatry and physiology. In the information-flow diagram of a successful model we may hope to find features representing concepts from each language. Some of the data of psychopathology even now can be translated into terms of information flow, so as to suggest testable physical hypotheses.[4]

I need hardly say that this is rather different from naively assimilating mental disorder to the ills of digital computers, a pastime which has justifiably irritated those more painfully close to the problem.

To summarize, the considerable effort going into this theoretical modelmaking is justified chiefly by the hope that out of it may come a way of describing the thinking process, sufficiently close to psychiatric realties to be useful in diagnosis, yet sufficiently operational and objective to allow the physiologist to make his maximum contribution to the study and treatment of mental illness.

You might call it conceptual bridge building—an activity set about with pitfalls and attractive to cranks, but withal one of the most promising ways of enlarging our understanding of what happens when we understand.

POSTSCRIPT ON PERSPECTIVE

May I conclude with a word of warning. This kind of inquiry is often misconceived—and sometimes attacked—as an attempt to "debunk man." "If my actions were nothing but the end-product of a chain of physical causes, where would things like my decision come in?" is a typical question. It may of course be true that people who do wish to "debunk man" imagine that a complete physical explanation of his brain would be grist to their mill. But if so I believe that they err in company with their opponents who base their arguments on the same premise. The villain of the piece here is usually the phrase "nothing but"—the hallmark of what we may call reductionist thinking.

If I say that an electric advertising sign is "nothing but" a certain array of lamps and wires, I may mean one of two things: (1) I may

[4] I have in mind, for example, those hallucinations that suggest diversion rather than absence of signals to correct the internal matching response.

mean that an electrician could make a complete catalog of all that is there, and have nothing left over, without mentioning "the advertisement." This is true. (2) Or I may mean that since there is nothing left over from the electrician's account, there isn't really an advertisement there at all. This is the error of reductionism. It consists in confusing exhaustiveness with exclusiveness. The electrician's account is exhaustive, at least in the sense that a perfect replica could be constructed from it. But the electrician's account and the advertiser's account of "all that is there" are not mutually exclusive. The advertisement is not something to be fitted into a gap in the electrician's account. It is something that we find when we start all over again to describe what is there in another complementary language.

It is not even possible to defend reductionism by the principle of Ockham's Razor, for this refers to a choice between alternative descriptions in the same language system, and not to a choice between descriptions in alternative language systems.

I suggest, then, that to try to find gaps for "my decision" in the physical chain of events in my brain is like trying to find gaps for "the advertisement" in the electrical description of the sign. "My decision" should find no place because it belongs to a different language, defined not from the observer's but from the actor's standpoint. There may well be links in the physical chain which have a certain margin of indeterminacy; but merely on linguistic grounds it would seem absurd to seek to fit "my decision" into what gaps they provide. "My decision" is surely rather my description from my standpoint of the whole pattern of activity, determinate and indeterminate.

It is not because I believe my brain to work indeterministically that I judge myself to be responsible. On the contrary, the more physically reliable my brain is, the less excuse I have from my responsibility. There is an unpredictability that goes with my responsibility, but that is something different. It is the unpredictability to you of what I shall do if you offer me your prediction. As a little thought will show, you would never be able to cope with this by allowing for the effect of your prediction on me, since I should always be one jump ahead of the data on which you could base your revised prediction.

To sum up, I believe most seriously that man is "more than" the physical organism which we can describe in observer language. But I believe that this implies not necessarily that there must be *gaps* in the physical account of his activity, but that he has other *aspects* that are revealed only by using another complementary language to describe the same activity, which in its full nature transcends and combines what can be said in both.

To explore the implications of this complementarity may throw some light on the age-old paradox that though we are but dust, we are

held responsible in the sight of our Creator. But of this responsibility, whatever our attitude to it, no increase in our understanding of the brain can relieve us.

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A Glimpse of Incomprehensibles

By George W. Corner

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One of the most interesting projects now under way at our laboratory is an experimental study of the behavior of uterine muscle. Dedicated as we are to the study of embryology, we are bound to consider the environment in which the embryo lives, and in particular that remarkable muscular organ, the uterus, in which every one has his first home. A visitor who steps into the rooms of Dr. Arpad Csapo, the leader of this particular research, sees him facing a mass of apparatus, tubing and wires, all of which is focused upon a small vial housing a strip of rabbit's uterus, three centimeters long. This bit of living tissue is kept at body temperature in physiological salt solution. It is supplied with oxygen and with energy in the form of dextrose. Its environment is thus made as much as possible like that within the intact animal. One end of the strip is fastened to a lever, so that when it contracts, as any involuntary muscle will do of its own accord when so prepared, its rhythmic contractions are recorded on a drum. Watching the lever move up and down, watching the muscle itself shorten and then relax, the fascinated observer realizes with a start that what he is watching is an engine, as much an engine as those which run our motorcars. Like them it has its own firing system by which the energy on which it operates is turned into mechanical work by a kind of explosion. Dr. Csapo chooses to supplant this natural "spark-plug" mechanism by mild electrical shocks from a mechanical timer; thus gaining somewhat smoother timing, he finds that he is indeed running an engine in the most literal sense. The experiment becomes quantitative, like an engineer's test of any steam or gasoline engine. The energetics of operation can be calculated. The work done is precisely related to the amount of contractile protein in the sample and of the fuel used. The strength of the contrac-

[1] Reprinted by permission from the American Scholar, vol. 23, No. 3, Summer, 1954.

tions (i. e., isometric tension) can be predicted from the size and physiological state of the muscle sample, and Dr. Csapo has even found a way, by the use of the ovarian hormones, to alter the mechanical performance in much the same way as when the pressure of steam supplied to a steam engine or the rate of carburetion of a gasoline motor is changed.

Thus far I have spoken only of isolated muscle tissue under fully controlled laboratory conditions; but we know also from very recent experiments by Dr. Brenda Schofield that the whole uterus in the rabbit's body operates on the same principle and would behave as uniformly except that it is affected by other complex regulatory factors, such as the nervous system and the ovarian hormones.

The nerves of the uterus apparently come into play chiefly for regulatory purposes on critical occasions; that is to say, the impulses they carry coordinate one part of the uterus with another when the fertilized eggs are to be received and accurately positioned in the uterus, and again when the infants are to be delivered. These nerve impulses are known to consist of ionic reactions; they and the blood flow that transports carbohydrate fuel to the uterus, in fact all the operative controls, are physicochemical processes. The whole organ must be regarded as a mechanism, no less than the isolated strip, although the intact uterus in situ is of course a more complicated mechanism and less uniform in its activity under experimental observation.

The investigator, for hours silently watching and controlling these experiments, inevitably asks himself, Is not then the whole rabbit also a mechanism, and if so, why not the man who watches? His muscles and nerves and brain that devised the experiment, his curiosity that asked the questions, the energy that drives him to answer them—is not all this the product of biochemical reactions under fixed laws of the physical world?

This is an old question, as old as philosophy itself, to which in the past an answer has often been given one way or the other by scientist or theologian. It was put again to me, not long ago, by one of America's eminent scholars. This friend of mine, a professor of literature, has a doctor son who works alongside of us; perhaps it was the younger man's enthusiastic talk of biophysics that disturbed the father. Perhaps also the professor, who is expert in the history of eighteenth-century thought, is still irked by the brash statements of mechanistic philosophy given two centuries ago by men like La Mettrie, author of books entitled "Man a Machine" and "Natural History of the Soul." At any rate, he asked me in all seriousness whether the advance of science and particularly of human biology does not threaten to reduce all human activity to physicochemical

terms and thus to destroy the humanities and do away before long with the arts and all learning, except physics.

In reply to the professor's question, I say in the first place that we anatomists, physiologists, and biochemists are for practical reasons bound to work on the assumption that the animals and parts of animals we study are indeed mechanisms. We must try as hard as we can to bring all animal and human behavior under observation and measurement. If the premature acceptance of nonphysical "vitalistic" forces leads us to abandon physical and chemical investigation, we shall only wander in a no man's land of conjecture.

In the second place, the progress of these sciences brings into the realm of materiality much that was once thought to be immaterial. One example of this will suffice. The phenomenon of vision was a great enigma to the ancients. Aristotle himself cried out in wonderment, "Who would believe that so small a space (as the eye) could contain the images of all the universe? What skill can penetrate such a wonderful process? This it is that leads human discourse to the consideration of things divine!" Since then we have marched steadily toward understanding human seeing as a physical and chemical activity. In Aristotle's time and in the Middle Ages, all existing knowledge was encompassed in a vague concept of the eye as the lantern of the soul. What we now call the lens was believed to be the central receptor of things seen, passing visual images inward to the soul itself. That the eye is a camera working on strict optical principles, and the retina its photoreceptor, became clear in the seventeenth century. In another hundred years, discovery of the optical nerve fibers made known that the brain is involved in the process of vision. The actual areas of the brain concerned in seeing, and the exact pathways from the retina to the cortex, were worked out in the nineteenth century; the biochemistry and biophysics of nerve conduction are the work of our own age. In view of all this progress toward a physicochemical concept of the visual process from eye to brain cortex, should the biologist be thought too daring if he now expects that biophysics will one day explain the conversion of cortical optic responses into conscious thought, and trace all the channels over which they reverberate throughout the body, causing the seer to stare or tremble or soar in ecstasy at what he sees?

We are indeed daring, I admit, when we predict that consciousness will be explainable in physicochemical terms, but nowadays even those who doubt the possibility of such understanding usually base their doubts not on grounds of vitalism or of piety, but on a materialistic argument involving a sort of uncertainty principle which states that a thinking machine is necessarily incapable of perceiving how it thinks.

Meanwhile, experimenters are attacking the citadel of the mind, the subconscious mind at least, by the study, for example, of conditioned reflexes. A clear description of one such investigation appeared in a recent number of the Scientific American, in an article by Professor Liddell of Cornell University on his experimental production of anxiety states in sheep and goats. By the simplest physical means, namely the continuous administration of slight painless electrical shocks on a monotonously regular schedule, he produced long-continued disorders of emotional behavior. Again, anyone who has observed the effect on human patients of drugs like desoxyamphetamine has seen how high-level mental phenomena, that is to say, elaborate apprehensions, conscious fears, and disorders of judgment, can be altered for the time being by a physical agent that can only be hastening or retarding, somewhere in the brain, some such purely biophysical action as the passage of ions across the borders of specific nerve cells.

Rather, however, than to carry this line of argument for the material nature of human thought to the length of saying outright, with La Mettrie, that man is a machine and even his highest activities are the product of physical reactions, let us go back and look again at the small living mechanism with which we started, the muscle strip studied by my colleague. Simple as it seems, this little engine is actually much more complicated than a man-made motor. It is not made of metal, but mostly of complex, unstable proteins. It is not able to burn ordinary hydrocarbons like wood, coal, or oil, but only one very special and elaborate substance, adenosine triphosphate. It has to make this fuel for itself from sugar brought by the blood stream, stepping up the chemical structure through at least a dozen enzyme processes until it has built what it can burn. It is not controlled by a throttle but by ion movements across a semipermeable barrier membrane. I have by no means stated all the complexities; if we could look inside this muscle when in action, we would see in each of its microscopic cells more ions, atoms, molecules, and larger aggregates going systematically about their business than all the people and automobiles in the city of Philadelphia. I once made a calculation that one cell of an endocrine gland, the corpus luteum, produces in one day more than a thousand billion molecules of its internal secretion.

The muscle machine is not only very complex; it is also very unstable. It runs well only within a narrow range of temperature; 60 degrees centigrade will cook it; one crystal of cyanide will stop it quicker than a monkey wrench in a crankcase. The protein molecules of which it is chiefly composed are held in a precarious state of teetering equilibrium by interacting tensions, like the gymnasts in a human pyramid. Such is life at the level of the cell. At the level of the organs—heart, lungs, liver—and at the level of the body, life consists of the interaction of such complex and unstable, there-

fore sensitive, tissues and their coordination by equally complex and unstable tissues such as nerves and blood vessels. At the level of the mind, the structure in which thinking is done is no less complicated. Dr. Karl Lashley, in a pioneering essay "In Search of the Engram," on the physiological basis of learning, closely estimated the number of nerve cells in the visual apparatus of the white rat from retina to brain cortex, and got a total of thirteen millions. With these neurones the rat is able to retain (says Lashley) scores, perhaps hundreds of visual habits involving discrimination of complex figures. The rhesus monkey has about a hundred times as many visual neurones; man, we may conjecture, a thousand times thirteen millions. A student reading his textbooks instantly distinguishes any one of ten thousand patterns presented by the printed words before him.

This enormous, overwhelming, almost inconceivable complexity of the human structure and mental function forces us, if we are to be materialists, into materialism of a new sort. When La Mettrie said that man is a machine, a machine to him meant something like a clock or the primitive Newcomen steam engine. He must have realized that the human machine is more complicated than that, but still it was to him, figuratively, a thing of cogs and levers. If, however, I say that man is a machine, I have to think of an apparatus much more complicated than the biggest electronic computing machine, and also much less stable, much more sensitive than any piece of man-made automatic hardware. The difference between old and new concepts of the living machine is so great, so fundamental, that twentieth-century scientific materialism is bound to be very different from that of the past. My variety of it, you may say when I finish, is not materialism at all.

Mention of electronic calculating machines brings us to the most recent aspect of mechanistic thought, the kind of analysis called cybernetics. This stems from the observation of certain similarities between electronic circuits and the structure and functioning of the nervous system. Not only is the transmission of the nerve impulse analogous to the electric current; not only are the synapses or nerve junctions analogous to electrical connections, and the primary reflex arc merely a doorbell circuit; more than that, something much like feedback wiring and regenerative circuits can be seen in the brain, suggesting the existence of stages of amplification like those of a radio set. On the contrary, some of the mental activities of men and animals can be imitated by machines built on these principles: for example, simple remembering, simple discriminations, even choice between alternatives simply presented. Some of these operations are fairly impressive. Everyone has heard what the great computing machines can do, for example, in solving complicated differential equations in a fraction of a second. When a wartime committee under my direction was studying devices for the blind, the engineer Zworykin of the Radio Corpora-

tion of America built us a machine that recognizes the individual letters of a printed alphabet and calls them off vocally. Another less serious engineer made a mechanical bug that knows when it is hungry for more juice in its little battery, trots off to the proper socket, connects itself and gets a recharge. If there is radio interference in the neighborhood, I suppose the gadget might develop a simple sort of nervous prostration like Professor Liddell's sheep and goats.

This jest of mine reflects the feeling of conservative anatomists and physiologists that cybernetic concepts fall far short of explaining the workings of the nervous system, partly, I admit, because we have by no means worked out a complete description of the animal machine for engineers to imitate. There are a lot of circuits and connections still to be traced. Yet the parallel onward march of neurology, biophysics, and electronic engineering makes it probable that all the operations of the animal mind result from the flow of electrical charges, that is to say, the transfer of ions in the cells of the body. When an experimenter produces neurosis in the sheep, or (to take a more agreeable example) when a hunting dog is conditioned to stand and point to a pheasant, I have no difficulty in supposing that the whole conditioning process occurs entirely on the material level. If asked whether I suppose this to be true also of more complex mental performances involving intricate choice of alternatives on the basis of a large stock of stored information, say, a fullback running through a broken field or Shakespeare writing a sonnet, I have to say I do not know. Even what I just said about the hunting dog is a hypothesis. We biologists are bound to work on such hypotheses, even if we do not expect that a good sonnet will ever be written by a man-made machine.

But suppose, just for the argument, that it is so, that all the higher activities of the mind—all that raises man above the unreflective beast and leads him to create arts, sciences, and humane learning—suppose that this is entirely the result of ionic shifts in our cells for which we may some day calculate the equations: what then? Do we scrap our libraries and colleges? Is my humanist friend whose question started me on this essay to discontinue teaching the history of literature and philosophy?

What I now reply is not the utterance of mystics or metaphysicians; it is the word of the histologist looking up from his microscope, the physiologist from his oscillograph. We see that the human thinking mechanism, if it is a mechanism, is utterly complex and multifariously sensitive beyond any conceivable instrument of metal and glass, and therefore its individual reactions will always be in large part unpredictable. Let me reinforce this statement by quoting again Karl Lashley, one of the most thoughtful of our neuropsychological experimenters. In this essay on the mechanism of learning, he writes:

The trace of any activity is not an isolated connection between sensory and motor elements. It is tied in with the whole complex of spacial and temporal axes of nervous activity. The space and time coordinates can, I believe, be maintained by . . . rhythmic discharges which pervade the entire brain, influencing the organization of activity anywhere. Within a functional area the cells acquire the capacity to react in certain definite patterns. . . . The characteristics of the nervous network are such that when it is subjected to any pattern of excitation, it may develop a pattern of activity, reduplicated throughout an entire functional area by spread of excitations. . . . All the cells of the brain must be in almost constant activity, either firing or actively inhibited. . . . The learning process must consist of the attunement of the elements of a complex system in such a way that a particular combination of cells responds more readily than before the experience.

The mental patterns of learning and of directed response, of which Lashley writes, are set up in an apparatus which in man consists of billions of neurones, interconnected through innumerable channels. The organ in which these patterns are stored is subject to excitation from outside through five senses, each of them so critically sensitive that a touch, a whiff of odor, can suddenly revive a whole chapter of the past—one chapter for me, another for you; one syllable heard may set off a torrent of emotion or activity. The mechanism is also sensitive to stimulation from within itself by stored memories, by organic sensations, by local subthreshold fluctuations of physical states throughout the body. Surgeons sometimes have an opportunity to stimulate the brain directly in a patient who is conscious and cooperative during an operation under local anesthesia. Dr. Wilder Penfield thus found that electrical stimulation at a single point of the cortex can elicit elaborate memories of things seen or heard. A big electronic computor has a bank of keys like a pipe organ; who can estimate the number of keys to the human mind, within the body and on the surface of its sensorium, through which impulses are thrown into one circuit or another, to start who knows how many oscillations in the next circuit, and the next? Nervous and mental operations involve, however, more than mere spread and flow of impulses. There are slowing and blocking resistors; there are shunts and diversions. There are circuits that operate to cut out other circuits, or to cut them in, or steady their oscillations. The elements of these circuits, moreover, are not copper wires, metal switches, and electronic tubes. The conducting threads, as well as the whole organism they interconnect, are made up of elaborate and unstable chemical substances, very critically responsive to changing conditions.

Their hookup into a vast network is also unstable and critically responsive. Integration of an organism so that this multiplex system will behave in a measurably constant way calls for all sorts of internal controls—the homeostatic regulators that Walter Cannon wrote about—and in higher animals on the behavioral level it demands

intensive habit formation by experience, training, and education. Even when such patterning of response is well established, the richness of internal communication is so great that a small resistance here, a sudden surge of mental current there, in the network may channel the impulses in a new direction.

It is these uncertainties that create individual differences in behavior and capacity. They direct and redirect for good or bad whatever is passing through our heads. They must in some way account for the mystery of original thinking and artistic composition. They will forever keep education from being a routine business.

The complexity of human thought and behavior is of course nothing new; my point is that science has caught up with that fact and now perceives that the bodily mechanism possesses a similar order of complexity and therefore may be assumed capable of conducting very complex and subtle operations. A recent experiment illustrates perfectly what I am trying to say. One subject of Liddell's investigation at Cornell was a nursling goat, three weeks old. When it was given the routine treatment of painless but unceasingly recurrent electric shocks, it developed the usual neurosis. This animal was one of twins. The other of the pair of kids was subjected to the same experimental treatment, except that its mother was left with it in the large stall where it lived during the period of exposure to emotional trauma. This second kid did not become neurotic at all. The presence of its mother had done something inside the little animal that kept its nerves from jangling. If its unprotected brother's neurosis was a mechanistic disturbance, from which the twin was protected by the comforting presence of a mother, then—at least in the case of these particular goats, under experiment by Liddell in a barn near Cayuga Lake—it looks as if the benefit afforded by the nanny's presence was also a biophysical phenomenon. But the scientist must admit that a mechanism that needs its mother is indeed a special kind of mechanism.

By such means as this, by the intercommunication of companionship, of mood, of sympathy and solace, individuals are integrated into still more complex organizations of flock and herd, family, tribe, and race. In this gift of communication, living organisms greatly excel the machines. We have all been astonished by Von Frisch's discovery of the signal language of honeybees. Certain man-made automatic control systems perhaps approach that achievement of the bees; but at a higher level how infinitely varied is the ability of human beings to transmit complex eddies of thought and emotion to one another!

Thus we have just about reached a truce in the old quarrel between vitalism and mechanism. Both sides perceive that whatever our respective hypotheses may be about the way things work inside us, we

too are creatures subject to repeated shocks, born to trouble, yet capable of adjustment. More complexly organized even than other creatures, we can go beyond mere mental adjustment, on to new accomplishments and achievements; but all the more do we need the influences that come through human kinship and the experience of our race, all that is learned at a mother's knee and at the feet of alma mater, and in the world of arts and letters.

When I mentioned the experiments at Cayuga Lake, some readers may have thought of a shepherd who once tended flocks beside another inland sea, who experienced in his own person both frustration and adjustment, and who being a poet saw the parallel between his own trials and joys and those of his sheep. Lifting his eyes to heaven, he said as of a greater Shepherd, "He leadeth me beside the still waters, He restoreth my soul." I have not chosen to carry, here, my concept of the new mechanistics into the field of religion. Science and theology tend to get heavy-handed with each other when discussing this subject. La Mettrie was banished and his books were burned because of his materialism. I think I do not risk any such fate because of mine. The biologist realizes that the mechanism is so sensitive to outward influences and to stimuli so subtle that current science is not able to define the limits of its sensitivity; and therefore, while in the laboratory he must base his own working hypothesis upon what he can see and measure, he will not in the present state of knowledge banish from the company of scholars any man whose personal hypothesis, or faith, takes him all the way with the high-hearted old scientific humanist Sir Thomas Browne, who bade us, "Have a glimpse of incomprehensibles; and thoughts of things which thoughts but tenderly touch. Lodge immaterials in thy head; ascend into invisibles; fill thy spirit with spirituals, with the mysteries of faith, the magnalities of religion, and thy life with the honour of God."

Biophysics will not soon measure the wavelength of exaltation like that; but even so, we shall go on exploring the body and brain. Let not my learned friend be troubled; if and when all the circuits are traced, when the last equation is written for the ionic movements that run the works in eye, ear, nerve, muscle, and viscera, the mechanism, however fully we then understand it, will still be complexly excitable and still sensitive to all the subtleties of a subtle universe. New combinations of neurones will go on being formed. Individuals will still be unpredictable. Patterns of behavior will still have to be established by training and education. Human history will not cease being made nor poetry to be written. If all the nerve cells are to be kept firing in the most effective sequence, some of the keys of the human mechanism will still have to be operated by the professors of languages and literature, by artists, and by philosophers.

The Electron Microscope in Biology[1]

By Ralph W. G. Wyckoff

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[With 2 plates]

Two recent developments in the human mind have contributed to produce modern natural science. One is a more acute sensory perception and objective awareness of the outer world. The other is an equally striking enlargement of the intellectual ability and willingness of many men to deal with these clearer perceptions of Nature, to relate them logically one to another, and to devise from these relationships a consistent pattern of outer happenings. This enhanced sensory awareness of external reality expressed itself in the painting and sculpture of the Renaissance; and more or less simultaneously there arose, sometimes in the same individual, that closer and more purposeful observation of natural phenomena which was a root of modern science. In art this clearer perception enriched immeasurably the world of human values that art serves; in science it began to furnish that basis of external fact which must underlie any sound understanding of the meaning of human existence.

Only a rudimentary natural science could, however, have arisen from such unaided observation, no matter how acute, or how carefully it was analyzed. The intimate knowledge we now possess of the texture of the universe is the direct result of the invention and use of instruments to extend and render ever more quantitative the limited information our senses can supply.

Vision is, of course, the sense that has taught us most about Nature; and it is therefore natural that instruments that extend its range will have been most actively sought and most highly valued. It was the telescope that gave a first practical demonstration of the essential role of instruments; the microscopes that began to be made soon after started the equally important observation of fine structure which has now become the chief preoccupation of modern science. Every branch

[1] Substance of a Friday Evening Discourse at the Royal Institution delivered on December 11, 1953. Reprinted by permission from Nature, vol. 173, March 6, 1954.

of science seeks first an accurate description of the gross appearance and behavior of its segment of Nature; and this has customarily been followed by the attempt to analyze the matter that is present into its components, and to ascertain significant relations between these components and the gross properties with which the original description was so largely concerned. In chemistry, this analysis has been achieved through the interpretation and correlation of elaborate series of chemical reactions. For certain other sciences, the microscope has been a much more direct analytical tool. Thus, the analytical stage for biology may be said to have begun when compound microscopes made accessible for study the individual cells that are the unit structures of living matter.

Since then, there has been a steady improvement in techniques of microscopy which, though providing very little extension in vision, have yielded a steady flow of new knowledge about the cellular level of organization. In our day, the electron microscope is of such exceptional importance because it does give such an extension, and one that allows us not merely to see smaller detail but also to reach in biology the deeper and more fundamental level of organization where molecules are the units. For the past 25 years we have known that the proteins and many other substances extracted from living matter have very large molecular particles. A number of these particles have already been seen under the electron microscope, and the fact of this visibility takes us beyond chemistry's conventional concern with statistical molecular aggregates to observations on separate molecules and their interactions. It is the principal object of this discourse to illustrate some of the more immediate applications we have made of this ability to see macromolecules.

Before doing this, however, I must give some idea of the great extension in vision already achieved with this new microscope. The limiting resolving power of any optical system defines its ability to portray small objects: it depends on the wavelength of the illumination we use. Optical theory has demonstrated that no microscope can possibly reveal the true shape of an object smaller than about half this wavelength. Accordingly, visible light cannot delineate objects smaller than about 0.2 micron (about a hundred-thousandth of an inch); with ultraviolet light we can do little better. Electron microscopes, though only about 15 years old as scientific instruments, have already portrayed objects more than a hundred times smaller than this in linear dimensions and hence more than a million times smaller in volume and weight. Such tiny particles are only 5 to 10 atoms across. The newly visible world having such relatively small molecules at its lower limit is about as extensive, and as full of unknown things, as that aspect of Nature which the optical microscope first

brought to light. It will take a long time to discern all that is here, and still longer fully to understand what we are seeing. In the meantime, we have all the excitement of seeing what no man expected to see, and of using much of the new knowledge thus gained to approach with clearer understanding many of biology's essential problems.

An indication of the relationship of the electron microscope to the familiar optical microscope may help in interpreting the images it produces. Seventy-five years ago, in 1879, Sir William Crookes demonstrated in the Royal Institution various forms of his new cathode-ray tube. The electron microscope is such a tube in greatly elaborated form. Like the Crookes tube, it has a source of electrons and a fluorescent screen to show their pattern; a magnetic field is commonly used to change their direction. In the electron microscope there are several of these fields, and they are so arranged that the electrons follow paths through the tube that imitate the path of light through the glass lenses of an optical microscope.

From a consideration of what an electron microscope is, it will be realized that there is no compelling technical reason why we should not have had some form of this instrument many years ago. Probably it was not built because its advantages become obvious only when our realization of the wave qualities of the electron started people thinking about it as an illuminant. Here is, in fact, a rather striking example of how our scientific imaginations may be bound by the ideas current at any time.

In science, as in most other fields of human endeavor, we rarely get everything we would like, and accordingly, it should not be a surprise that there are important limitations to what can be looked at under an electron microscope. For the most part these arise from the relative impenetrability of matter by electrons; therefore, the object must be extremely thin and, after thorough drying, it must be examined under the vacuum of the tube. This is not an overwhelming disadvantage, but it makes necessary new methods of specimen preparation that will preserve the structures we are interested in, down to their finest molecular details.

To delineate very small objects we must look at their very highly magnified images; this involves magnifications far greater than those useful in optical microscopy. The detail seen in the best optical microscopes becomes increasingly "fuzzy," indistinct, and meaningless when viewed at magnifications above about 1,500 ×; but we can now have electron micrographs in which detail is sharp at 150,000 ×. Occasional electron micrographs are worth studying at twice this magnification. These magnifications are so vastly in excess of any in our previous experience that most of us find it difficult to have a vivid realization of how very small are the objects we are seeing.

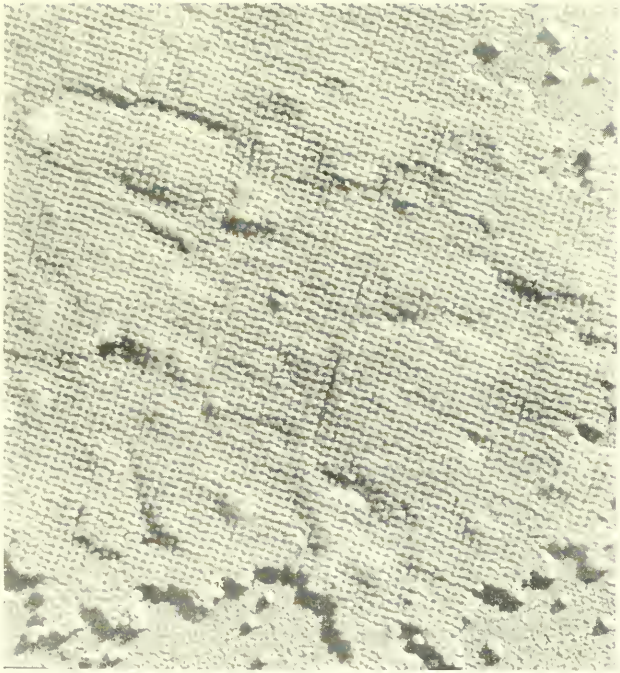
Many novel problems arise when we use the electron microscope to see molecular particles. In it, objects are visible by reason of the electrons they deflect, or scatter; and a molecular particle is able to deflect very few compared with the substrate that must be used to support it. This lack of a necessary contrast in the resulting image can be met by evaporating a few atoms' thickness of heavy metal obliquely over a preparation. Then contrast is enhanced by the little atomic shadows cast by molecular and other detail, and these have the added advantage of giving the image a three-dimensional quality that reveals the shapes of what we see.

There is one very important difference between the practice of optical and of electron microscopy, made necessary by the destructive effects of powerful electron beams. In general, the optical microscopist does most of his work visually and only occasionally takes a picture. The electron microscopist, on the contrary, uses visual images mainly to find and to focus on fields of interest. By then taking pictures on fine-grained photographic film and enlarging them later, he is able to obtain very high and useful magnifications without employing the destructive electron intensities that would be needed to give bright images at these highest enlargements.

It is impossible to do more here than show what a few typical macromolecular particles are like, and indicate some of the problems dealing with them that are now claiming our attention. In essence these problems are threefold. They involve recognizing and measuring the particles, determining how they are arranged in the structures they form, and trying to find out how they are produced in Nature.

The proteins that occur in solution in a living organism offer many examples of approximately spherical macromolecules. When sufficiently purified, these substances often crystallize well, and we can study with the electron microscope various stages in the growth of the single crystals they form. The photographs that have been obtained from a number of proteins and plant virus proteins show the beautiful molecular order that characterizes all steps in crystal formation (pl. 1, fig. 1).

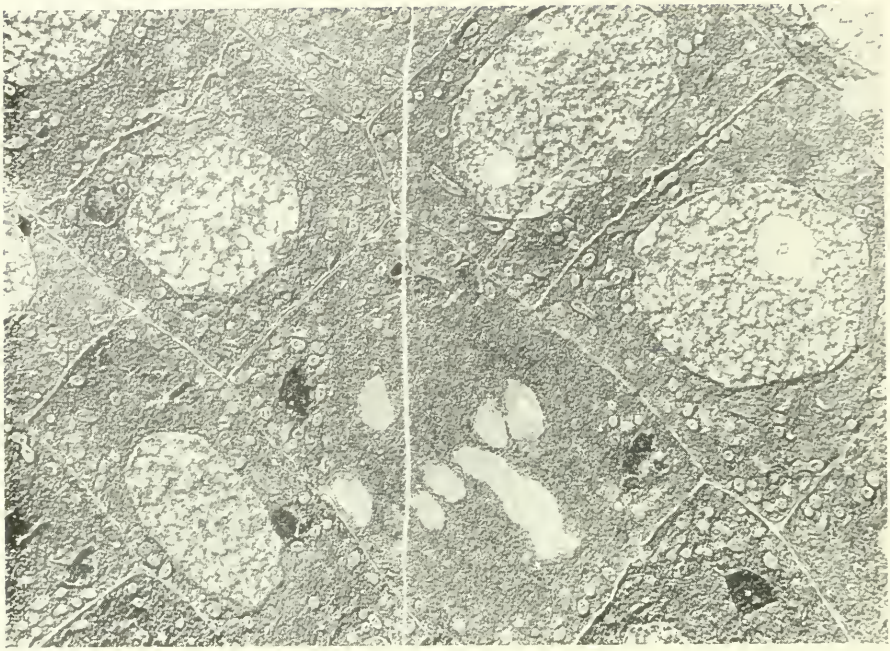
Another highly important type of molecular particle is a long filament. The thicker among these are relatively stiff and straight, like the tobacco mosaic filaments in old solutions or the elementary particles of cellulose. Those that are thinner are wavy threads. Solutions of the muscle proteins, of collagen from connective tissue, and of the nucleic acids contain such threads; some that have been photographed are less than 10 atoms in diameter. Paracrystalline, rather than crystalline, solids composed of these filamentous macromolecules are among the important framework structures of plants and animals. Their investigation is one of the most rewarding of the current appli-



1. Early stage in the crystallization of a necrosis virus protein. The orderly arrangement of the particles is apparent. × 46,000.



2. Section through a swollen tendon. Two or three unswollen fragments show their 650-A. striations. × 17,500.



1. Section through an onion root tip showing parts of several resting and one dividing cell with its (sectioned) chromosomes. × 8,200.



2. A mass of influenza virus particles developed from a cell. × 9,000.

cations of electron microscopy. Filaments display a striking tendency to assume parallel arrays. Thus, the secondary walls of plants consist of stacked sheets of parallel-aligned filaments of cellulose. Striated muscle has a parallel alignment of molecular threads as a sort of backbone for its other components. Sections cut at right angles to a muscle fiber demonstrate many fine details of an ordered packing of these threads that in some places is almost crystalline in its perfection. Evidently the kind of knowledge that will result from such observations permits an entirely new approach to the problem of muscular contraction.

An equally good but very different type of molecular order prevails in tendon and other forms of connective tissue. Collagen, for example an Achilles tendon from the heel, has been examined as shredded fragments and in sections cut in various directions through an intact tendon. At low magnifications not much above those used in optical microscopy, one sees the tiny fibrils that are associated together in bundles and sheets to form the macroscopic tendons. Higher magnifications reveal the fine structure of each component fibril. The examination of transverse sections suggests that a fibril is enveloped by a tube of collagen; preliminary swelling shreds the collagen and shows how its macromolecular particles are knitted together to produce such a tube (pl. 1, fig. 2). Collagen dissolves in very dilute acids and alkalis and can be reprecipitated from its solutions. The electron microscope demonstrates that under certain conditions these re-formed fibrils have the molecular fine structure of the original collagen, but that under other conditions of precipitation fibrils of different fine structures are produced. Some of these are found in Nature, others are not. Such investigations of the various forms of collagen are important, not only for their bearing on the nature of paracrystalline order, but also because they permit us to study the changes in connective tissue that accompany and perhaps may sometimes be responsible for arthritis, rheumatism, and similar degenerative diseases of man.

When we seek to deal with the third broad field of study opened up by electron microscopy—how these macromolecular particles arise—we immediately realize the need first for an adequate picture of the fine structure of the living cells that produce them. Most of what we know about the cells that constitute the higher plants and animals has been gained from optical microscopic studies on thin sections of their tissues. To extend our observations to electron microscopic magnifications it has been necessary to learn how to cut sections that are about fifty times thinner than those required for this optical work. Such wafers of tissue only a few millionths of an inch thick can now be cut as a matter of routine. With them we are beginning to survey again some of the problems of bacteriology and many problems of

histology and embryology from the point of view of the new detail that is to be seen. Artifacts formed during specimen preparation obviously are more troublesome the finer the structures being studied, and new methods must be developed before we can utilize to the full the potentialities of the electron microscope. Nevertheless, the progress already made has revealed far more than we can yet interpret within sectioned tissues.

Innumerable questions can be answered from the examination of healthy cells. If they are from plants we can, for example, follow the growth of their walls and we can examine the fine structure of their chloroplasts, of their starch grains, and of the many other objects to be seen in their cytoplasm. If they are of animal origin, we can inquire into the elaborate mitochondrial and other structures that are particularly striking in cells of special function such as those in the liver or kidney, in the eye or the nervous system. With both plant and animal cells we can approach from this finer level of organization the mechanism of cell division (pl. 2, fig. 1).

These studies of components of the normal cell and of how they develop supply the background requisite for investigating the abnormalities of cell life that are responsible for many diseases of living matter. Virus diseases are among the first of these to which we naturally turn, both because the viruses that cause them are too small to have been visible before and because, whatever their nature, these pathogenic agents stand on the borderline between the animate and inanimate and thus offer a unique opportunity of learning more about the essence of the living state.

My laboratory in the United States at the National Institutes of Health has been particularly concerned over the past few years with this study of virus growth, and we have learned much about how several viruses develop within the cells that are their hosts. There appears to be no uniform pattern for this development, and one cannot briefly describe the various types of virus growth we have seen. Nevertheless, I would like in conclusion to indicate what we have found about one familiar virus—that of influenza. From an examination of purified suspensions, we know that its infectious particles are either tiny spheres or filaments of the same diameter. In sections through diseased tissues we find these virus particles not within the infected cells themselves, as many of us would have expected, but clustered around their peripheries and developing from them as filaments that break off and segment into spheres (pl. 2, fig. 2). Such observations with the electron microscope demonstrate that the elementary infectious units of this virus have not proliferated after the fashion of minute micro-organisms but instead are bits of cytoplasm of the diseased cells.

The particles of several other viruses, including bacteriophages, are derived from the protoplasm of the host cells; but there are other viruses that do not have such an origin. Some appear to arise from specialized components of the diseased cell, whereas others may be foreign invaders that multiply like micro-organisms, by growth and division. Much more observation is needed before the full story of virus growth is known; but it is important that we at last have a method capable of giving this knowledge.

At this early stage in our explorations with the electron microscope it is not possible to foresee what new insights into the vital process it will next give us. Perhaps they will come as we address ourselves more and more toward the small viruses, especially those that attack nervous tissue; or perhaps we shall find more immediately rewarding the closer study of the numerous structures that are steadily being found as we examine a widening range of healthy cells. Whichever it is, we may be sure that our visual penetration of the macromolecular level of organization will prove steadily more fruitful as experience gives us an increasing ability to interpret the new things we observe.

Reprints of the various articles in this Report may be obtained, as long as the supply lasts, on request addressed to the Editorial and Publications Division, Smithsonian Institution, Washington 25, D. C.

The Spread of the Cattle Egret[1]

(With particular reference to North America)

By Alexander Sprunt, Jr.

National Audubon Society

[With 3 plates]

There is certainly no one avian species that, in the twentieth century, has created the sensation produced by the cattle egret (*Bubulcus ibis ibis*) in the United States. Its presence is at once unique and without precedent. At no other time in history has a bird appeared on the continent of North America and become established as a breeding species without man's assistance. As phenomenal as this fact is, and despite the consuming interest created in the bird-minded public of this country, it seems proper here to comment on the species in a world sense as well as in the Americas.

The cattle egret, cow heron, or buff-backed heron, as it is variously called, occupies an extensive world range and is a wide wanderer. Two varieties exist—*Bubulcus ibis coromandus* and *Bubulcus ibis ibis*. The ranges of the two are as follows:

Bubulcus ibis coromandus[2]	India, Ceylon, Burma, Siam, southern China, Korea, southern Japan, Formosa, Hainan, Philippines, Sunda Islands, Celebes, Ceram, Buru; occasional in New Guinea and Australia.
Bubulcus ibis ibis	Southwest Palearctic, Ethiopian and Oriental regions. Breeds in southern Spain and Portugal; in North Africa from Morocco to Egypt and south of the Sahara all the way to South Africa; in Asia in southwestern Arabia, Syria, Transcaucasia and northern Iran; also in Madagascar, Comoros, Seychelles, and Mauritius. Occurs on the coast of the Mediterranean and Black Seas, and in Iraq. Accidental in Britain, Denmark, Hungary, southeastern Russia, the Canaries, and Madeira.

[1] Valuable assistance in the preparation of this paper was rendered the writer by the following: Herbert Friedmann, Willard E. Dilley, Samuel A. Grimes, Herbert L. Stoddard, Louis A. Stimson, Richard Bird, and Alexander Wetmore.

[2] Lat. *Bubulcus*, concerning cattle; Gr. *ibis*, ibis; Lat. *coromandus*, crown-mantle.

Description.—Breeding plumage: White, with crown, neck, and upper back pink to orange buff. Legs yellow to dull reddish; feet dark brown. Bill yellow, shading to reddish orange near base; rather stout and blunt. Irides yellow; lores dull orange. Winter and immature plumage: Almost wholly white, crown sometimes pale buff; legs yellowish black to greenish black with soles yellow; bill yellow.

OLD WORLD STATUS

Africa.—Herbert Friedmann, curator of birds in the U. S. National Museum, informs me that the cattle egret has increased markedly in South Africa in recent years. On his first trip there in 1924 he saw only a few individuals and all of them in one locality. In 1950 he found them "very numerous in almost all places visited." C. J. Skead has recently studied the status of the species in eastern Cape Province and has published findings in the Ostrich, vol. 23, No. 3, pp. 186–218, December 1952.

In discussing the definite increase in that region Skead states that he has found no explanation for it, nor has he established any directional movement which might indicate whence the birds have appeared.

Australia.—This continent presents some interesting facts regarding the cattle egret. All things considered, something of a parallel exists there as it does in the Americas in that the bird *may* have become established without man's assistance. However, it is certain that one attempt to introduce it was definitely made. Whether subsequent developments stem from that effort seems rather improbable, but one must judge from the evidence, and here it is.

In 1933, 18 birds were introduced into the Kimberly Division (Serventy and Whittell, Handbook of birds of western Australia, 1948). This attempt apparently did not succeed in establishing the species. In 1950, Tarr, writing in the Emu, vol. 49, pp. 191–192, was not able to find any other attempt at introduction.

Herbert Deignan, associate curator of birds of the U. S. National Museum, added the cattle egret to the known fauna of northern Australia in 1948. He then saw flocks of as many as 100 birds and obtained two specimens at Oenpelli, Northern Territory. It is his very reasonable opinion that the group of 18 birds that were introduced in 1933 and that disappeared could hardly have been responsible for the hundreds he saw at a locality 400 miles away years later. Much of the country intervening is totally unsuited to the bird's needs. Therefore, he suggests that it must be considered at least that the birds in the Northern Territory are the result of a "nonhuman dispersal." The cattle egret is a notorious wanderer; of that there has been, and still is, abundant evidence.

England.—The following interesting data are quoted from Witherby, Jourdain, et al., Handbook of British birds, vol. 3, p. 144, 1939:

> A considerable number of . . . *coromanda* [the Asiatic subspecies of *Bubulcus ibis*] . . . have been released by the Zoological Society each year since 1931 at Whipsnade, and a few were also released in 1930 by Mr. A. Ezra at Cobham, Surrey. These birds have wandered in all directions and have been reported from time to time in many parts of the country as far apart as Devon, Somerset, Monmouth, Wiltshire, Leicester, Notts, Merioneth, Kent, Essex, Cambridge, Norfolk, Lincs, Perth, and even Iceland.

This account very definitely shows the tendency of the bird to scatter far and wide, a characteristic that should be constantly borne in mind.

NEW WORLD STATUS

SOUTH AMERICA

British Guiana.—The first specimen of the cattle egret (African form, *Bubulcus ibis ibis*) in the New World was obtained by Emmet R. Blake, near Buxton, East Coast, British Guiana, May 27, 1937. It was an adult female (Auk, vol. 56, pp. 470–471, 1939). How the species arrived in British Guiana is still a mystery. Reference to this is contained in F. Haverschmidt's article in Audubon Magazine (vol. 55, No. 5, p. 202, September-October 1953), and is quoted herewith.

> We do not know where the cattle egret landed in South America, nor when. . . . Naturally the question arises how did this bird arrive in South America and where did it come from? There is in my opinion no reason to doubt that its spread is a natural one. I have heard some rumors that some people think that some birds were taken as pets by laborers from India into the Guianas. This can be rejected at once, however, as in that case the birds must have been of the race inhabiting southern Asia which is not the case, as all birds obtained in South America are of the race of southern Europe and Africa.
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> A fact is that of late years the cattle egret has increased greatly and also has extended its range in Africa, for instance, in the Eastern Cape Province. . . . They occur as migrants in the nonbreeding season in the Congo, Cameroons, etc. . . . Could it not have been possible that a flock of these migrating birds were blown to the west, owing to special weather conditions which brought them over the Atlantic at some place on the coast of tropical South America? Here again, because of the lack of field observers, it could have happened all unnoticed.
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> We further may ask whether all the cattle egrets now found (in So. Amer.) are the descendants of one single flock which survived the first crossing and which settled down in a favorable area. Or does some immigration still regularly take place? We cannot give an answer to all these interesting questions, but the unhappy feeling remains that a wonderful event has occurred about which we know very little.

Any student of this "wonderful event," as Mr. Haverschmidt very aptly calls it, is urged to read his article in its entirety, for it is a very clear picture presented in popular and readable form.

In addition to Blake's record may be mentioned a letter written in June 1946 by P. S. Peberdy of the Museum at Georgetown, British Guiana, to Dr. Alexander Wetmore to the effect that the cattle egret occurs in loose groups of from 10 to 40 individuals, chiefly around the ricefields and ponds along the coast of Demarara. Although no specimens were collected prior to Blake's 1937 example, Peberdy claims that Robert Hunter observed large flocks on his hacienda in 1930. (Letter reproduced (in Spanish) by Phelps and Phelps, Bol. Soc. Venez. Cienc. Nat., vol. 10, p. 231, 1946.)

Venezuela.—The first reference to *Bubulcus ibis ibis* from Venezuela seems to emanate from W. H. Phelps (Auk, vol. 61, p. 656, 1944). Therein he discusses the possibility as to whether the specimen secured on January 27, 1943, near San José de Tiznados, Guárico, by Octavio Arleo B., of the Caracas Museum, was a "straggler from Spain or North Africa, or whether the specimen in hand was an escaped captive bird." This was the second known specimen collected in South America. It was shot from a group of four; the others "looked exactly the same" (to Arleo). Apparently the existence of the bird in British Guiana was not then known to Mr. Phelps, or at any rate he made no mention of such. He did say that "there is a passenger line of steamships from there (Spain and North Africa) to Venezuela." The specimen was obtained "many hundreds of miles from the seacoast" (prairies of the Apure River, in the Orinoco Valley). It was recorded by Walter Dupouy as the first Venezuelan record (Mem. Soc. Cienc. Nat. La Salle, año 4, No. 11, pp. 1–11, 1944).

The second Venezuelan specimen is recorded by Phelps in Bol. Soc. Venez. Cienc. Nat., vol. 10, p. 230, 1946. The third, a specimen shot at Laguna "La Angulera," approximately 15 kilometers south of Valencia, state of Carabobo, on February 2, 1947, by Humberto Giugni, was reported by Dupouy (Mem. Soc. Cienc. Nat. La Salle, año 7, No. 19, pp. 174–178, May–August 1947). The fourth, reported as the third because Dupouy's paper was unavailable to them at the time, was a specimen recorded by Herbert Friedmann and Foster D. Smith, Jr., under the title "A Contribution to the Ornithology of Northeastern Venezuela," in the Proceedings of the U. S. National Museum, vol. 100, p. 411, 1950. This was a male obtained August 25, 1948, at Cantaura, Anzoátegui. These authors have written for the Proceedings (vol. 104, No. 3345, 1955) an account entitled "A Further Contribution to the Ornithology of Northeastern Venezuela" containing the following:

> We recorded a Venezuelan example of this heron in our earlier paper. It has since been steadily increasing around the collecting stations. From 1945 through 1950 only one flock of 4 individuals was seen, that recorded by us. In 1951 the bird was recorded three times: 2 individuals, February, Caicara; a single, August, Cantaura; a single, October, Caicara. The 1952 records are as



1. Pair of cattle egrets in willow tops. Lake Okeechobee, Fla. May 5, 1953.



2. *Eubulcus ibis ibis* in King's Bar Rookery, Lake Okeechobee, Fla.

(Photographs by Samuel A. Grimes, Jacksonville, Fla.)



1. Typical posture of *Bubulcus* with grazing steer. Eagle Bay Ranch, Okeechobee, Fla.



2. Cattle egret–snowy egret contrast. *Bubulcus* at lower right. King's Bar, Lake Okeechobee, Fla. May 5, 1953.

(Photographs by Samuel A. Grimes, Jacksonville, Fla.)



1. Cattle egret on nest amid willows. King's Bar Rookery, Lake Okeechobee, Fla. May 5, 1953.



2. Courtship behavior in the rookery. King's Bar, Lake Okeechobee, Fla. May 5, 1953.

(Photographs by Samuel A. Grimes, Jacksonville, Fla.)

follows: 10, August, about 10 kilometers south of Urica; a single, September, Cantaura; 5, October, Caicara; 10, December, Caicara. In January 1953, a flock of 6 was seen at Caicara and a flock of 8 about 10 kilometers south of Urica, Anzoátegui.

Surinam.—In the Auk, vol. 64, p. 143, 1947, Haverschmidt records by sight observation the first instance of the species in Surinam. He saw the bird near Nieuw Nickerie, March 10, 1946. On March 30, 1947, he obtained a male, this specimen being now in the Museum of Zoology, University of Michigan, Ann Arbor (Auk, vol. 70, p. 364, 1953). Haverschmidt refers to the above in his article in Audubon Magazine as follows:

> In this country (Surinam, Dutch Guiana) it reaches, as far as we know, its present southern limit in South America. . . . By December 1946 it became apparent to me that the cattle egret was quite a numerous bird in the cultivated coastal area of Surinam, wherever cattle were kept. . . .
>
> Most of them roosted in the bushes along the Surinam River opposite Paramaribo. The greatest number of birds that I counted in this roost was about 600. . . . The Hindustani peasants were astonished at this strange fellow who came stalking the birds with a gun, and loudly protested against my wish to collect specimens for the scientific record. . . . In the Nickerie district . . . the birds have certainly increased since I first saw them in 1946. Here they have a large roost in the low bushes bordering the Nickerie River. . . . In the late afternoon of May 28, 1953, I counted 1,112 birds using this roost.

Colombia.—The first cattle egret recorded for Colombia was a female secured at Punto Muchimbo, Valle, on the lower Río San Juan, January 3, 1951. It was immature. The specimen was listed as an addition to Colombia by Alexander Wetmore (Additional forms of birds from Colombia and Panama, Smithsonian Misc. Coll., vol. 117, No. 2, p. 1, 1951).

R. M. de Schauensee (Birds of Colombia, Caldasia, vol. 5, p. 1144, 1952) records another specimen taken at Chía, Bogotá plateau of the eastern Andes, at an elevation of 2,562 meters. It was obtained November 25, 1951. About a month later a bird was seen near the Caribbean coast in the lower Río Magdalena region (Palmar de Varela, Atlántico), the date being December 30, 1951.

Dugand (Lozania, No. 8, pp. 1–7, January 1954) has recently summarized the Colombian records and has added additional cases to the ones given above, showing that the bird has increased and spread rapidly in northern Colombia.

Bolivia.—Niethammer (Journ. Ornithol., vol. 96, pp. 222–223, 1955) reports a specimen taken at Irupana, Yungas, 1,950 meters elevation, on December 3, 1953.

Netherlands West Indies.—While in service with the U. S. Navy, W. H. Drury, Jr., saw the cattle egret at the island of Aruba in 1944 (Auk, vol. 70, p. 365, 1953).

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SUMMARY OF SOUTH AMERICAN DATA

Probably no one has done more, or even as much, work with the cattle egret in South America as Haverschmidt. His published findings have evidenced wide knowledge of, and great interest in, the species, and it might be well here to redigest his opinions and conclusions.

From the bird's sudden appearance in British Guiana in 1930 and its subsequent occurrence in the countries of Surinam, Venezuela, Colombia, Bolivia, and the Netherlands West Indies, the explanation of its actual origin remains unknown. Haverschmidt (Auk, vol. 67, p. 381, 1950) suggests three possibilities:

1. The bird was always indigenous but was overlooked.

2. Birds comprising the present population are descendants of escaped birds.

3. Some birds somehow found their way to South America from Africa and, the area where they landed being suitable to their needs, settled there and increased.

He considers Nos. 1 and 2 extremely unlikely and believes that No. 3 is the solution. I agree completely. Such behavior has been characterized as "explosive migration." Considering the bird's spread in Africa and to Australia, to say nothing of its normal tendency to wander widely, this expression seems appropriate. A good illustration of it would be the result of liberation from the Whipsnade Zoo and the subsequent appearance of cattle egrets as far off as Iceland.

The greatest number of birds checked at one observation was Haverschmidt's count of 1,112 at the Nickerie River roost. One of the most surprising statements in all his publications of the bird appeared on page 204 of the September-October issue of Audubon Magazine (1953) in which he says:

> It is . . . highly unsatisfactory to be aware that the bird has been present in South America for more than 20 years, yet there is not a single breeding record for it in any of the countries where it now regularly occurs.

He goes on to say that he has never found it in any regular heron rookery and that it is not a bird of the mangroves or coastal mud flats. Further, that "The nesting places of the cattle egret must be sought in some inland and freshwater marsh." He assumes that the breeding season is from April until July. (See below, in connection with the North American nesting which, in all details, corroborates Haverschmidt's conclusions.) He concludes his illuminating account by saying that he never saw a cattle egret on the back of a cow and he doubts that it ever takes "ticks" from the skin of cattle. (See under Behavior, below, regarding observations in Florida.)

WEST INDIES

(Since the manuscript of this paper was originally written, cattle egrets have appeared in Cuba and the Virgin Islands.)

NORTH AMERICA

As far as I can ascertain, the first sight record of the cattle egret in North America should be credited to Willard E. Dilley, then of Clewiston, Fla., now on the staff of the Everglades National Park. Though the writer made this statement in his article in Audubon Magazine (July-August 1953), the date of Dilley's observation there given is erroneous. It was stated to be May 1948. Recent correspondence with Dilley has provided the following information. Under date of May 26, 1954, he writes in reply to my request:

> My wife and I moved to Clewiston in January of 1941. I entered the service of the United States Navy during the summer of 1943, so the occurrence was somewhere during this period. From memory I would place it as the summer of 1941, but it could have been the summer of 1942.
>
> There were two birds present; one, a full-plumed bird . . . the other showing just a trace of rust on the head. They were in a marshy pasture which lies between the sandy ridge of Clewiston and the government dyke. They remained in this area for a week.

Dilley did not record the observation, as he considered the birds escapees. There is every reason to believe now that the ones he saw were among the first to appear in the United States. The exact time and place of the original appearance will probably never be accurately known, as the birds were very likely overlooked for some time. Certainly there is now evidence that practically proves that they were in Florida for some time before coming to the attention of ornithologists. An illustration of this is provided in a recent letter to the writer from Samuel A. Grimes, of Jacksonville, Fla., who has taken a great interest in the species. On a population survey of the cattle egret in May 1954, he talked to a man living near Belle Glade (south shore of Lake Okeechobee) who told him that he had seen cattle egrets feeding "regularly with cattle for two or three years up to the time of the flood (hurricane) in 1949." This would place birds there in 1946 or 1947.

The gap between Dilley's Clewiston birds (1941 or 1942) and the Belle Glade observations is unexplained, as well as the interim succeeding and lasting until the summer of 1951 when the species appeared at Cape May, N. J. This was a single specimen, and where it came from and how it succeeded in reaching New Jersey without being reported en route are mysteries.

1952.—It was in the year 1952 that the cattle egret really came into prominence and produced the sensation now current. And yet, with what is now known, the species had in all probability been present in this country for a decade! That seems incredible, but the facts, being

what they are, are inescapable. The most reasonable explanation would appear to be that there were a few scattered birds seen with white herons feeding with cattle—so commonplace that no one thought of examining any closely.

At any rate, the definite establishment of the species in this country was by means of photography, but the photographer did not realize that history was being made on his film! On March 12, 1952, Richard Borden was photographing white herons with cattle on the Eagle Bay Ranch, northeastern shore of Lake Okeechobee. He assumed that they were snowy egrets. Later in the spring, after returning to his home in Massachusetts, he examined this film in detail because of the fact that the cattle egret had appeared in that region, and it was found that Borden had pictures of the species without being aware of having taken them.

Slightly more than a month after he had made the film, the first cattle egret to be obtained in this country was taken near Wayland, Mass., by W. H. Drury, Jr., A. H. Morgan, and R. Stackpole, on April 23, 1952 (Auk, vol. 70, p. 364, 1953). These observers saw Borden's film and confirmed the fact that some of the white herons at Eagle Bay Ranch were *Bubulcus ibis ibis*. Borden later commented on his achievement in the Bulletin of the Massachusetts Audubon Society (April 1953, p. 139) under the title "Was My Face Red?" In this interesting article he undertook, with good reason, to needle me for not having discovered that the bird was present in the Okeechobee area where I was conducting Audubon wildlife tours and passing the Eagle Bay Ranch four days each week! My only explanation lies in the above-mentioned fact that white herons feeding with cattle were so much a part of the local scenery that they were simply pointed out to visitors as such, often at some distance.

From that time on, records began to multiply and take form. On June 1, 1952, Louis A. Stimson, of Miami, Fla., saw 10 cattle egrets on the north shore of Lake Okeechobee, 17 miles west of Okeechobee City, at the Indian Prairie Canal. Knowing that I was then engaged in a revision of Howell's "Florida Birdlife," he at once notified me of this observation. Stimson has continued to take an active interest in the species in Florida, and many of his findings will be mentioned later.

During the summer of 1952, two cattle egrets appeared at Cape May, N. J., and were seen by numerous observers. Stimson reported one bird at Lake Harbor (south shore of Lake Okeechobee) on August 24, and four at the same place on August 31. The next report was from Massachusetts, where one bird was seen near Cambridge (Charles River) November 27–28, and one was taken on November 28 at North Truro.

The 1952 records came to a spectacular close when a specimen was

taken "in the autumn" aboard a fishing boat off the Grand Banks of Newfoundland! Fortunately it was preserved and the skin shown to Roger Peterson and James Fisher, in April 1953, by Leslie Tuck, Dominion wildlife officer. This constitutes the first record for Canada (Audubon Mag., vol. 56, No. 1, p. 6, January–February 1954). Thus, in the year 1952 the cattle egret was seen, or obtained, from the extremes of south-central Florida to Newfoundland!

1953.—The first birds of 1953 were reported by Stimson who, on February 11, saw several near Bear Beach (south shore of Lake Okeechobee). The next day Audubon Warden Glenn Chandler, stationed at Okeechobee and long since alerted to watch for the species, came to my house in Okeechobee with the news that he had just seen his first specimen at Eagle Bay Ranch, in the same pasture where Borden had taken his photographs. On the 13th Mrs. Sprunt saw four birds there. Samuel A. Grimes, who was visiting in Okeechobee at the time, saw his first specimen on the 15th at Eagle Bay, and I saw my first at the same place later in the day.

On February 27 Dr. and Mrs. Powell Cottrille, of Jackson, Mich., photographed 12 birds near Belle Glade, and from then on, through March, the bird was seen by every Audubon wildlife tour group, as many as 25 being seen at a time. All these observations occurred in the Eagle Bay area. The population of the northern lake shore group was, as near as Stimson, Grimes, and I could figure, about 50 birds. It was known that the numbers on the south shore (Belle Glade to Clewiston) were higher, but how much so was uncertain.

May 5, 1953, was a memorable day in American ornithology. On that day Grimes and Glenn Chandler found the first cattle-egret nest in North America. It was in a heron rookery on King's Bar, an island in Lake Okeechobee, 3 miles off the mouth of the Kissimmee River. It held one egg and was photographed by Grimes. Chandler attempted to show this nest to Roger Peterson and James Fisher a few days later, but it had fallen out of the willow in which it had been built and crumpled in the water beneath. A snowy-egret nest close by was mistakenly pointed out by Chandler as that of the cattle egret before the collapse of the latter was discovered.

On May 30 Grimes returned to the rookery, accompanied by Herbert L. Stoddard, and five more nests were found. Stoddard obtained a male cattle egret, the first specimen to be taken in Florida. Thus a new species was added to the breeding avifauna of a continent.

It was also in this month (May) that the species appeared in Virginia for the first time. Two birds were seen on the Chincoteague Wildlife Refuge (eastern shore) on May 13 by J. H. Buckalew, then refuge manager.

During the late summer and fall of 1953 Chandler saw very few birds on the north shore of Okeechobee, which seems strange. How-

ever, they were present in numbers on the south shore, Stimson noting 35 on August 30. Cape May again showed birds that summer. John K. Terres, writing under date of August 20, said, "I saw four cattle egrets on August 2, 1953, at Cape May." They were in the same pasture frequented by the birds in 1951 and 1952 (McPherson farm).

In order to stimulate and facilitate observation in Florida, Stimson prepared a "Brief Field Description" of the bird, which appeared in the Florida Naturalist, vol. 26, p. 185, October 1953. Under date of November 8, 1953, Mrs. Frances Hames of Key West, Fla., wrote me as follows:

> I think you will be interested to know that cattle egrets are in Key West . . . They are feeding on grasshoppers and dragonflies and occasionally they go to a pond (fresh) across the street and get a drink of water. One bird shows a definite glow on the crown, otherwise they appear pure white.
>
> I had not expected to see the cattle egret here because he is supposed to be a bird of "open cultivated country and not of the mangroves and mudflats along the coast."

There were four birds under observation by Mrs. Hames, and their occurrence brings up interesting speculation. Where did they come from? This is, of course, the southernmost record for the United States, and at the same time these birds were seen in Key West others were appearing in the Miami area! Hitherto, none had been reported south of Lake Okeechobee, 75 miles to the north across the Everglades. At any rate, from November 8 to November 18 as many as 26 birds at a time were noted near Homestead on a farm on Mowry Drive. These were watched for that period by Stimson, Willard Dilley, and Joseph Moore of the Everglades Park staff, and others. Groups of 9, 10, 11, 12, and 18 birds were seen on various days. The smallest group was 4 birds, the largest 26.

Stimson, writing of these birds under date of November 28, 1953, asks: "What is going on? Are more birds coming up from South America, or are these down here going to South America?"

On November 21, on a trip from Miami to Clewiston, and from South Bay to Bear Beach, west along the southern shore of Lake Okeechobee, he had counted 105 cattle egrets. Going east of South Bay to about Pahokee, he found two groups, one of 15 birds, the other of 32. Thus in that day from Bear Beach to Pahokee, he counted 152 birds. Knowing what we do now regarding the breeding of the species on the south shore of Lake Okeechobee (see below) it seems certain that the numbers seen by Stimson were simply birds that had nested, or had hatched, earlier in the season in that area. It seems equally reasonable not to consider that any of these birds were migrating southward, or that some had done so. Therefore, the Key West and Homestead birds may well have been new arrivals from South America.

November brought another new locality into the North American scene—the island of Bermuda. Writing under date of November 29, 1953, Miss Patricia Browne of "Leeholme," Devonshire, reports the following:

> I would like to report the presence in these islands of at least three *cattle egrets*. It is the first time that they have been recorded here. . . . On November 12 while passing a field, my attention was drawn to what I thought were immature little blue herons. I became curious however, as they were feeding very close to several cows. I rushed home and re-read the article by F. Haverschmidt in the Audubon Magazine. . . . I returned to the field and had a careful look. The three birds . . . had a heavy, yellow bill and dark legs. . . . I was able to take photographs of the bird with the cow but only from a distance . . . The owners of the cows said that they had noticed three of these birds during the past two weeks, always in close association with the cows. One reported seeing them perch on the cow's back.

Miss Browne very kindly sent me several pictures and the bird shown is without doubt *Bubulcus ibis*.

The year 1953 ended with an astonishing illustration of the wandering of this species. On December 8, a farmer near Brownfield (near Portland), Maine, killed a strange bird which he said was "disturbing the chickens." He took it to a Portland taxidermist who mounted it and placed it in his window. I was advised of this remarkable incident by Christopher M. Packard of the Portland Society of Natural History in a letter dated December 18, 1953. The specimen was presented to the Gorham State Teachers College by Chief Game Warden Elmer Ingraham.

1954.—I went to Okeechobee early in January and was there until the end of April, conducting the twelfth season of the Audubon wildlife tours. Cattle egrets were seen this year a month earlier than last. Except for the first tour (January 12–13) the species was seen on every trip through the month of April. This probably indicates that it is now so well established on the north shore of Lake Okeechobee as to be a permanent resident.

Early in 1954 the cattle egret appeared again in the lower Florida Keys. Under date of January 25, Harry E. Stiles of Grand Rapids, Mich., who had been in Okeechobee earlier that month, wrote me that on a subsequent trip to the Keys he had seen and talked to Jack Watson, the biologist in charge of the protection of the Key deer. Watson had seen and watched three birds in his deer area (Big Pine, Torch, and Cudjoe Keys) for several days. No exact date was given, except that it had transpired shortly before Stiles arrived in the area. The birds had disappeared shortly before, but Watson had found a fourth dead on the highway a few days previously. It developed that this specimen had been frequenting the shoulders of the road and feeding on insects disturbed by passing cars until eventually struck and killed! An interesting adaptation to conditions.

It is possible that the four birds noted by Watson were the same reported by Mrs. Hames at Key West about 2 months earlier. Watson's area is some 30 to 40 miles east, and the Key West birds were seen on November 7, 1953. It may well be that they were wandering eastward along the Key chain in a leisurely manner. Mrs. Hames observed one bird later in the spring, March 29, 1954, at Key West.

The cattle egret again nested at King's Bar, Lake Okeechobee, in the spring of 1954. Warden Chandler was watching this locality from mid-April and reported to the writer late in that month that the birds were present in the rookery. A trip was made there on May 1 and birds were seen at the nests. Early in May the second nesting locality for the species was found about 200 miles north of Lake Okeechobee. On May 2, 1954, Dale Rice, of the Department of Biology, University of Florida, found an adult feeding three young in a nest at Lake Alice, part of the university campus, Gainesville, Fla. He estimated that six birds were "using the rookery." He did not state whether this represented three pairs, but such is assumed. He had been watching the area for some time, knowing that cattle egrets were in the vicinity, and believing that they would breed there. He adds that they were not there last season (1953). (For further nesting data in 1954 see below.)

Before going further in the year it should be noted here that one more new locality was established about this time, this being the State of New York. On May 20 a single specimen was seen on a turkey farm near East Moriches, Long Island, by LeRoy Wilcox. This information was given to the writer by Richard A. Sloss, of Woodmere, Long Island, in a letter dated June 7, 1954, which stated in part, "The bird had appeared here approximately four days previous to this date (May 20) and disappeared early the following week. His diet consisted mainly of angleworms."

PANAMA

There have been several sight records for the Canal Zone by Maj. Francis O. Chapelle and Eugene Eisenmann (unpublished) and for the Province of Panama by David Fairchild. Reports from a reliable native hunter to A. Wetmore indicate that the bird was present in considerable numbers in 1954 in the savannas near Pacora.

NESTING

From the rather meager data hitherto available, this much can be said regarding the nesting of the species in the United States. It has congregated with other herons in normal rookery procedure, living in close proximity to snowy egrets, little blue and Louisiana herons, anhingas, boat-tailed grackle, limpkin, gallinules, and Florida ducks. The nests are the usual platforms of dead sticks hardly more substantial than those of its heron neighbors.

The eggs number three or four and measure (on an average of four) 1.80 by 1.35 inches. The writer is in possession of the only set of eggs in the country, these being the first collected in North America. They are of the same shape as other medium-sized heron eggs but are definitely paler, the color being a very light bluish white. No data is as yet available on the incubation period but it should hardly vary from the usual heron interval.

The young are fed by regurgitation, as in the case of other species. Grimes found, in his investigations of the King's Bar nesting (1953), that the food was very largely insect material. No conflict has been noted between the cattle egret and native herons in the three rookeries where they have thus far nested. The most recent rookery found and investigated was examined by Grimes and Stoddard in mid-May 1954 in a marshy area of Kreamer's Island, southern Lake Okeechobee. In a letter dated May 27, 1954, Grimes says:

> The rookery itself contained a rock-bottom minimum of 200 nests and possibly double that number . . . there were more cattle egrets than all other herons combined . . . there were young in most of the nests (from newly hatched to fairly well feathered) but some still held eggs. Young would average three to a nest. We saw a number of broods of four and two or three sets of five eggs.

Both he and Stoddard agreed that the number of nests would be nearer 300 than 200, but the latter figure was given in order to be ultraconservative. This is, of course, by long odds the largest rookery of this species and has probably been the source of supply, so to speak, for some years.

BEHAVIOR

Those familiar with ornithological works of the Old World will, of course, be familiar with the general habits of *Bubulcus ibis*. However, in an entirely new range such as the United States, it may be well to stress some of its habits in general. No bird is better named, whether one calls it cattle egret or buff-backed heron. In view of the fact that it will probably be known more generally by the former designation, it is well to say that such a term is absolutely appropriate. Associations between certain birds and animals will come to mind but none is more striking than in this instance.

As Haverschmidt says, it is not a bird of mangroves and mud flats—no cattle frequent such habitats and *Bubulcus* is attracted to cattle as filings are to a magnet! It will be recalled that Mrs. Hames wondered at the presence of the species at Key West because that area is mangrove and mud flat. The actions of the bird there, as well as of the individual killed along the Overseas Highway (taking insects disturbed by motor cars), were merely adaptions to immediate environment. So the cattle egret is to be looked for where cattle occur. Other white herons feed with cattle, sometimes alighting on their backs (I have seen both snowy and immature little blues do this), but thus far,

curiously enough, I have not seen a cattle egret do this, though many others have. (I have since seen such behavior once.) Mrs. Sprunt witnessed a curious incident during the winter of 1954 at Okeechobee. She was watching a cattle egret feeding beside a cow that was grazing at the side of a canal. The cow started down the canal bank, followed closely by the egret. The animal entered the water, the bird jumped up to its back, rode across the canal thereon, and as the cow climbed out dropped off to the ground on the other side!

The close proximity maintained by the bird to cattle is little short of astonishing. It is a positive wonder that they are not stepped on! It keeps pace with the animal continually, usually close by the head but sometimes near the fore or hind feet, and occasionally under the belly. When an insect is disturbed, the bird darts out, secures it, and returns. Now and then, it reaches up and picks off something from the body of the cow, or its legs. Whether these tidbits are flies, ticks, or what, I do not know, but it is a frequent practice. At times, the cow may be seen to push the bird aside with its muzzle, but appears not to object otherwise to the immediate closeness of its satellite.

A very peculiar and, as far as I know, unexplained characteristic of the bird is the habit of weaving the head and neck from side to side. It is a most interesting bit of behavior to watch. A bird will suddenly stop feeding, stand perfectly upright, and weave the upper part of the body in a sort of hula-like motion. After a few of these movements it resumes feeding. This habit has never been witnessed in any native herons of this country in the writer's lifelong experience with all of them.

On one occasion during February 1954, in the Okeechobee area, I was informed that cattle egrets had been seen feeding with horses in the same manner as cattle. This is not to be wondered at in a cow country.

The standing position of the bird is rather erect. The neck is short and thick, compared with a snowy egret, and the plumes are much shorter and with no recurve at the tip. The flight is performed with rapid beats of the wings and the neck is carried in the usual heron manner.

FOOD

The food of the cattle egret is, of course, an important consideration in evaluating its status, both present and future, as a new species in the New World. Generally speaking, it varies rather widely from the usual conception of heron diet (aside from the snowy egret's tendency to take insects at times). As far as is now known, the following can be said with some certainty:

Grasshoppers figure to a very considerable extent. So, also, do crickets. Sloss mentions that the Long Island specimen took angleworms. Mrs. Hames stated that dragonflies figured in the food of

the birds at Key West. Mrs. Sprunt saw a cattle egret take a frog at the Eagle Bay Ranch near Okeechobee; another bird saw it and attempted to rob the original captor. During the ensuing fracas the frog escaped but was recaptured and swallowed by the bird that first secured it. Frank W. McLaughlin wrote under date of May 21, 1954, that he had seen a bird on May 2 in Burlington County, N. J. (pine-barren area), catch and eat a Fowler's toad (*Bufo woodhousii*). After sweeping it back and forth through water, it tossed the toad upward, then caught and swallowed it head first. Two or three others were obtained while he watched.

In a letter dated December 16, 1953, Roger T. Peterson says, "I was interested to learn that you [the present writer] had seen them [cattle egrets] take ticks off cows." Actually, as said above, I do not know whether what the cattle egret takes off cows are ticks. The birds certainly take something off the legs, neck, and belly of cows frequently. Peterson says that "every author I have read indicates that ticks are very unimportant in the diet of the cattle egret." This may very well be so elsewhere, and maybe in this country. Ticks have certainly been drastically reduced in the cattle ranges of Florida in recent years; of that there is no doubt at all. But this needs further study.[3]

COMPETITION WITH OTHER SPECIES

As far as is now known there is no competition whatever in this country with other herons. The diet of the cattle egret is definitely different from most of the herons of the United States. The feeding territory is, as a consequence, also different. Other than the tendency of the snowy egret and little blue heron to feed occasionally along with cattle (though never in the close proximity maintained by *Bubulcus*), there is no parallel. In rookeries there is no lack of nesting sites. Cattle egret nests are placed within a few feet, or even inches, of those of other herons, but this is perfectly normal in any rookery. It is rather too soon to say anything about nesting success, but all evidence indicates that it is as great as that of any other species under similar conditions. The rather rapid increase of the cattle egret in only a short time (in Florida) would seem to prove that the majority of the eggs are hatched and most of the young are raised.

CURRENT POPULATION

The present population of the cattle egret is, of course, concentrated in Florida. Even there it is rather definitely localized, mostly in the area about Lake Okeechobee. Hitherto it has been difficult to be anything like precise in estimating the numbers, but the recent work of Grimes and Stoddard has added considerably to our knowledge.

[3] Since the above was written, I have seen the bird take flies off cattle.

Small groups have been noted about Hialeah (Miami) in the pastures north along State Road 27 and in the Homestead area to the south. This is as far south as the bird can be expected to occur, as there are no grasslands below this region. The scattered individuals noted in the Keys can hardly have been anything but wanderers or perhaps new arrivals from the Tropics.

The group that nested in the Gainesville area in the spring of 1954 may well settle there and form a nucleus of increasing numbers. There is considerable pasturage in the region, providing a conducive habitat. The few occurrences of individual birds in such widely scattered localities as Sarasota (west coast) and Merritt's Island (east coast) are inconsequential.

The great bulk of the population remains about Lake Okeechobee in two general groups. The smallest of these occurs along the northeast shore of the Lake from the Kissimmee River to the Eagle Bay Ranch, a distance of some 5 miles. The writer covered this area 4 days a week for nearly 4 months during the winter and spring of 1954 on the Audubon wildlife tours, and arrived at the conclusion, supported by others, that it is frequented by about 50 birds.

The larger group frequents the southern shore of the Lake from about Pahokee on the east to Clewiston on the west. While it has been realized for some time that the birds here far exceeded those of the north shore, it was not until Grimes and Stoddard discovered the Kraemer Island rookery in May 1954 that actual numbers could be stated. Quoting again from Grimes' letter of May 27—

> Right now, counting eggs and young, there are at least 1,100 or 1,200 cattle egrets in the rookery, and, if you figure 300 pairs (which we both agreed would be a more likely estimate), there are 1,500 to 1,800.

In the King's Bar rookery (north shore group) there were about 20 nests this season, which is practically double the number of 1953. The production of young this season should well be 50; therefore, the northern group may now be placed at 100. The Gainesville birds thus far, including young, would hardly number more than a dozen. What with a few wandering individuals here and there, it may be said with a considerable degree of assurance, that the current population of the cattle egret in this country as of July 1954 is very close to, if not quite, 2,000 birds.

This figure certainly bears out the belief held by Grimes that the species has been in Florida much longer than was at first thought. Also, it seems clear that the few birds observed in 1941 or 1942 by Dilley were the first breeders. As Grimes notes in his letter, "If only a single pair came originally, it would have had to be in 1943." Such an assumption seems justified.

REACTION TO SPECIES ESTABLISHMENT

From a commercial point of view, the cattle industry should be most concerned with the spread of the cattle egret. The bird is insectivorous, and its diet consists in large part of destructive insects. Its consumption of grasshoppers and other insects injurious to grass is of definite benefit to pasturelands. Comparatively few cattlemen are aware of the presence of the cattle egret, though they know that white "cranes" are a common form of birdlife in the grasslands. Ranchers in the Okeechobee region to whom the writer has talked are glad to have the birds in their pastures and would welcome an increase in their numbers.

FUTURE INCREASE AND SPREAD

Regarding the future increase and spread of the cattle egret, little can be said now. That the species is a wide wanderer has been proved in this country as well as in the Old World. It is entirely likely that Florida will remain the center of population for some time to come. Much of that State is eminently suited to the bird's needs, with food and nesting sites in abundance; and, the cattle industry being what it is, the habitat will probably remain unaltered. Stoddard's opinion is that it will come to be the dominant heron in certain areas and that both increase and spread will be rapid.

Occurrence of the species has been recorded, in an over-all sense, from Key West to the Newfoundland Banks; the Atlantic seaboard States reporting the presence of the bird are Florida, South Carolina, Virginia, New Jersey, New York, Massachusetts, and Maine. There is also one fairly credible occurrence in the Chicago region. Considering that appearances of the cattle egret in New Jersey and Massachusetts have exceeded two each, the fact that none have as yet been reported from Georgia or North Carolina seems remarkable. It is to be presumed that all the northern records are of birds wandering fom Florida, though the possibility exists that other regions may be represented. Secured specimens, however, have all been *Bubulcus ibis ibis*—not *coromandus*. Additional localities to those above will doubtless be visited by ornithologists, perhaps in the near future,[4] and future records obtained.

FIELD CHARACTERS

With the ever-increasing number of bird students throughout the country and the great interest in the cattle egret, many observers are

[4] The farthest-west occurrence of the species (except the somewhat indefinite Chicago record) has been reported from Bay County, Fla., near Port St. Joe. One bird was seen there May 23, 1953, by Roy C. Hallman. This, and the bird seen near Tallahassee on July 9, 1953, by Henry M. Stevenson, are the only occurrences thus far west of Tallahassee.

on the watch for it. Therefore, it might be well to recall certain diagnostic field marks which will identify the bird at once. Generally speaking, for the benefit of amateur observers, I should say that the cattle egret looks like a yellow-billed snowy egret. Any really good look at the bird, however, will at once reveal that the beak is short, stout, and stubby, in comparison with the slender and longer black beak of the snowy egret. The entire plumage is white, with the adult showing the orange-buff on crown, neck, upper breast and back. The legs are dark in the immature, yellowish in the adult.

NOTE.—Since the above was written, information of the highest importance has been received in connection with the lack of South American breeding records. Rumor reached the writer in an indirect way that the nest *had* been found on that continent by Richard Bird, of Regina, Saskatchewan. A letter was sent to him, to which he replied under date of June 18, 1954, from Banff, Alberta, where he was engaged for the summer. He did not have his notes with him there, but he gave the following information:

> From memory, it was in 1950 that we [his wife and himself] were in British Guiana and photographed these birds in several locations in that British Colony, making both motion pictures and stills of the *nesting birds*. [Italics are the writer's.]
>
> As near as we can remember the dates and locations . . . it was in May or June and the locations were: some miles up the Berbice River; on the Demerara River a few miles from Georgetown; in some marshes a few miles west of Georgetown; up the Abary River some miles from the coast; and a small colony nested in the Botanical Gardens near Georgetown.

So the distinction of discovering the first known nesting of *Bubulcus* in South America goes to a Canadian! Haverschmidt is undoubtedly in possession of the information now, but of course did not have it when he wrote in Audubon Magazine. As he predicted, the nesting locations were away from the coast.

The Migration of Mammals[1]

By L. Harrison Matthews

Director and Permanent Secretary, Zoological Society of London

[With 1 plate]

When I was asked to write of the migration of mammals my first thought was, "Hardly any of them do"—and compared with birds, the proportion of the 8,000 different sorts of mammals that have regular migrations is certainly very small. In fact the characteristic thing about the majority of mammals is not that they migrate but how near home they stay. Many mammals have a home range—a "territory"—in which they spend practically the whole of their lives, and from which they seldom or never wander. This applies particularly to those small mammals that live in burrows, or nests, which form the center of their territories. The normal range of the common long-tailed field mouse, for example, covers only a trifling area, and it is unusual for an individual to travel more than a hundred yards from the center of its territory. Rabbits usually live their whole lives in the warren in which they are born, and do not go more than two or three hundred yards away for their daily grazing. This attachment to territory also applies during the breeding season to the more nomadic kinds as well, for many animals that may be considerable wanderers for part of the year have to become static when their young are born, and have to make a home in which they can be reared.

Carnivorous mammals usually have a hunting territory centered upon a home, a den of some sort. They work this territory but do not need to go beyond its bounds. Their food is concentrated high-grade protein, and they may need to make a kill only at intervals of several days. Unlike the herbivorous mammals they are not compelled to be always feeding.

The larger herbivorous mammals—the grazers and the browsers—must feed on and off all day, because the green herbage they eat has a comparatively low food value. So the larger sorts must have a wide grazing range, and in consequence their territory is often not well marked. In Africa, for instance, many of the grazing mammals follow the rains and the new grass that springs up afterward; they thus undertake an irregular sort of migration through an extensive but ill-defined territory.

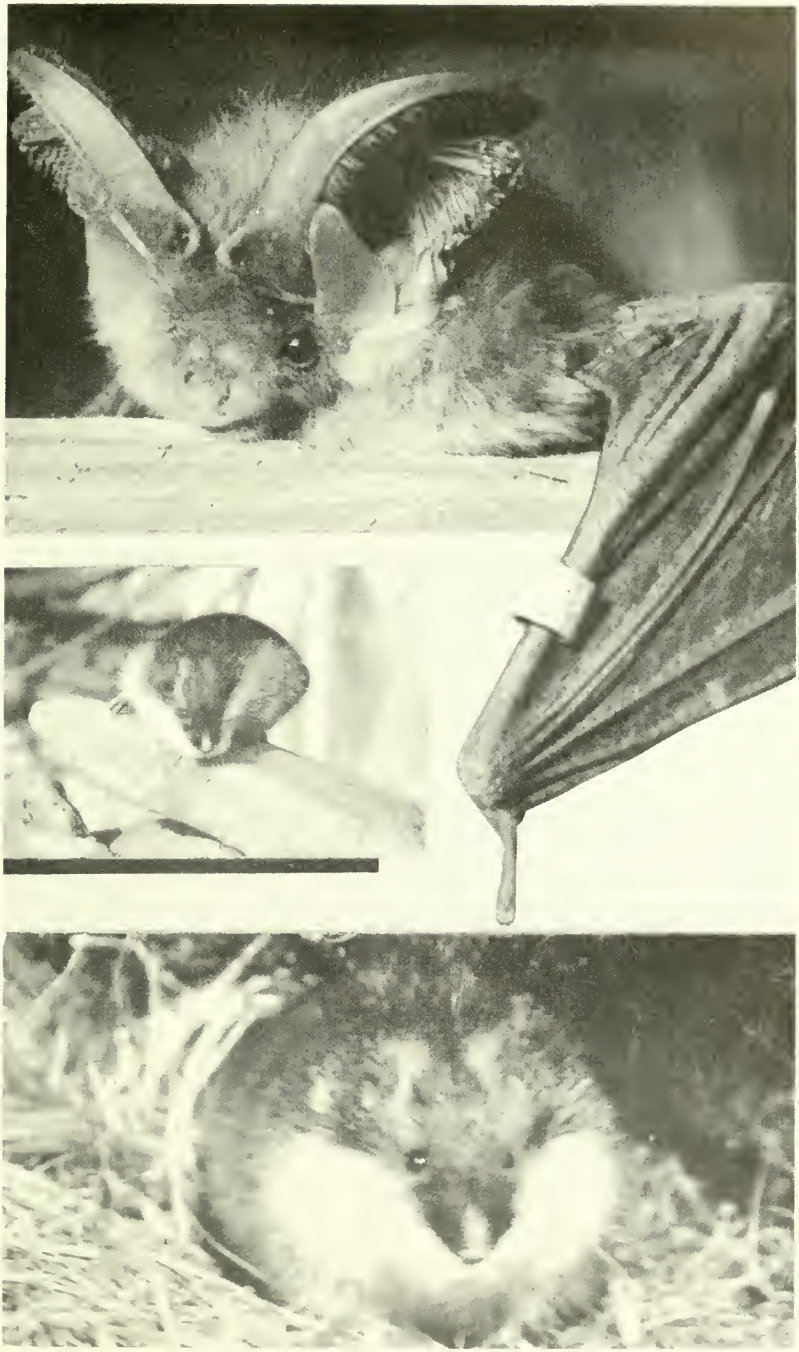
[1] Reprinted by permission from Discovery, vol. 15, No. 5, May 1954.

There are, however, mammals that make regular migrations similar to those of birds. In these there is a seasonal movement of the whole population, with a return at a later date: the movements are either to reach good feeding grounds, a more congenial climate, or a suitable place for breeding. But unlike the free-flying birds, land mammals have to make extensive and possibly difficult journeys on foot—rivers, mountains, and arid regions are insuperable barriers to travel, so it is not surprising to find that comparatively few land mammals migrate. They are mostly the large and long-legged sorts that can travel fast and so can protect themselves from predators and other hazards of migration. It is especially the mammals that live in a uniform medium that are able to migrate on a scale comparable with that of birds. They are the mammals that live in the sea and can swim, or live in the air and can fly: the whales and seals on the one hand and the bats on the other.

Let us consider first the land mammals. The mammals that migrate on foot must obviously be those that live on the large continental land masses, if their travels are to extend to any considerable distance. Land migration, too, must obviously be over ground that is reasonably good for traveling; apart from topographical barriers such as mountains or deserts, tropical forests are almost impenetrable for anything but local movements.

It is in North America particularly that we find several species of land mammals that migrate; by contrast, in Asia, Africa, and Australia there are few. There is good reason for this. It is probably correlated with the topography and climate of the continents. In North America there are great differences of climate in different latitudes, and in addition the main mountain masses run north to south; in Asia the hotter south is divided from the cooler north by mountain ranges running east and west: in Africa the climate varies from subtropical to tropical but there are no arctic regions from which a winter migration might be necessary.

In North America the larger migratory mammals traverse lands that are open steppe or savannah, or are covered only with comparatively open forests. The American mammal whose migrations have attracted most attention is probably the caribou, a species of deer like a large reindeer. But the movements of the herds are by no means constant and it is therefore very difficult to form a clear idea of their migration routes. In some years the herds mass together in great numbers so that the migration is an impressive sight; in others the herds are broken up and the deer pass by in small bands that give the impression of a scarcity. And the herds of different regions take different routes, so that they do not appear to obey any uniform rule. All that one can say is that in general they seem to follow a circular



Upper, a long-eared bat marked with a numbered aluminum ring. Devon "cavemen" have ringed over 1,800 bats belonging to seven species. (Photograph by J. H. D. Hooper.) Center and lower, photographs of lemmings, taken by Frances Pitt in Norway. The lower animal is an adult; the one in the center is somewhat more than half grown.

counterclockwise course during the winter, and then to bear away northwest to the barren lands in spring. In the Mount McKinley area of the Alaska range, however, the caribou that spend the summer on the southern slopes actually move over in the winter to the northern side where the snowfall is lighter. The migrations of the caribou are connected partly with the food that is available, but they are connected to an even larger extent with the appearance of the clouds of mosquitoes that make life a misery for man and beast. Shortly after the deer move north the mosquitoes emerge in almost incredible hordes, but as soon as the mosquito season is over the caribou return to their winter quarters and thus they miss the worst of the mosquito plague farther north.

The other large North American migratory mammal was the bison. It was long doubtful whether the bison was a truly migratory mammal, but the analysis of a great mass of old records by the American naturalist E. T. Seton has plainly shown that it was. But here again the migration routes were not simply to and fro from north to south, but were more or less in circular clockwise paths, some of the herds joining one circuit, others another circuit. And the winter quarters of at least one circuit were in the northern part of the range, although other herds moved southward from 200 to 400 miles at the approach of winter.

Many other land mammals have similar seasonal migrations, though on a much smaller scale. Our own red deer move down from the higher hills during the winter to the less severe conditions of the valleys, but the distances covered in such movements are trifling compared with the journeys performed by birds, some bats, and the aquatic mammals. At the other end of the scale a migration to be measured in yards rather than miles occurs every year when in the autumn our population of feral house mice moves in from the fields to the corn stacks. Such local movements of limited extent are commonly found in the smaller mammals.

A kind of population movement that should not be confused with true migration, which is essentially an outward journey followed by a return, is the periodical emigration that is found in some species. In this there is an outward journey, but no return; the animals that quit the land of their birth perish and leave no offspring to come back. The most familiar example of an animal that emigrates is the lemming of Scandinavia. Lemmings are small mouselike rodents that normally live high up on the Norwegian mountains close to the timber line. Their numbers, like those of many small rodents, are subject to periodical cycles of increase and decrease, which may reach an astonishing size; as their numbers increase the population is crowded out of its normal range and overflows down the hillsides. Finally, when it

reaches a peak, there is one of the famous "lemming years," when the animals swarm all over the countryside, moving of necessity in a westerly direction. Thousands are drowned in the rivers and fjords; and then the population crash comes and they die out, leaving comparatively few survivors on the hills to start building up toward the next peak. Similar cycles, though on a smaller scale, are known in other rodents, for example our own short-tailed vole and the American gray squirrel. The journeys of vast hordes of springbok that used to occur in the appropriately named "Trekkbok" years in South Africa were also emigrations, and not true two-way migrations.

But none of these terrestrial mammals can undertake migrations similar to those that are so well known in birds, where a whole population transfers itself in a few days or weeks over a great distance, often hundreds of miles, to a seasonal territory, and where the dates of arrival and departure vary only within narrow limits. It is only the mammals whose movements are unrestricted, because they fly in the air or swim in the sea, that can make migrations in any way comparable with those of birds.

A few species of small bat make regular migrations from summer quarters in the north to winter ones in the south, although most bats seem to get over the difficulty of having no winter supply of insects to feed upon by giving up the struggle and hibernating. Some, however, particularly in America, do not hibernate, but migrate far to the south to warmer regions where food is abundant. Two species in particular are known to migrate, the red bat and the hoary bat. They spend the summer in the northern United States and migrate down the Atlantic seaboard of America to the southeastern States in the winter. There is no doubt about the southern migration, for the bats have been both seen and captured on their passage, not only on land near the coast but far out at sea. But hardly any have ever been seen on their return journey, and beyond the fact that they are present in the north again during the summer, there is little direct evidence to demonstrate their northern journey. Some of the European bats, too, are said to migrate but the known facts prove only that a local movement takes place, and no long-distance travels have been shown to occur. None of our British bats migrate to other countries for the winter; they all hibernate. But the hibernation of some of them is not so complete a winter sleep as has been sometimes thought. Members of the Devon cave club have recently marked a very large number of horseshoe bats with aluminum rings so that they can follow up their movements. The result of this work shows that although the bats hibernate, they keep on waking up at intervals during the winter, and sometimes travel distances of many miles from one cave to another during these wakeful periods. Horseshoe bats live in caves during the winter, but they migrate to other quarters in the summer; no one

knows quite where, but it is certain that many of them take up residence in such places as the roof spaces above the attics of old houses, and the roofs of churches.

In the Tropics there is a well-marked migration in some species of large fruit-eating bats, or flying foxes as they are called. In the gray-headed bat of Queensland there are regular mass movements of

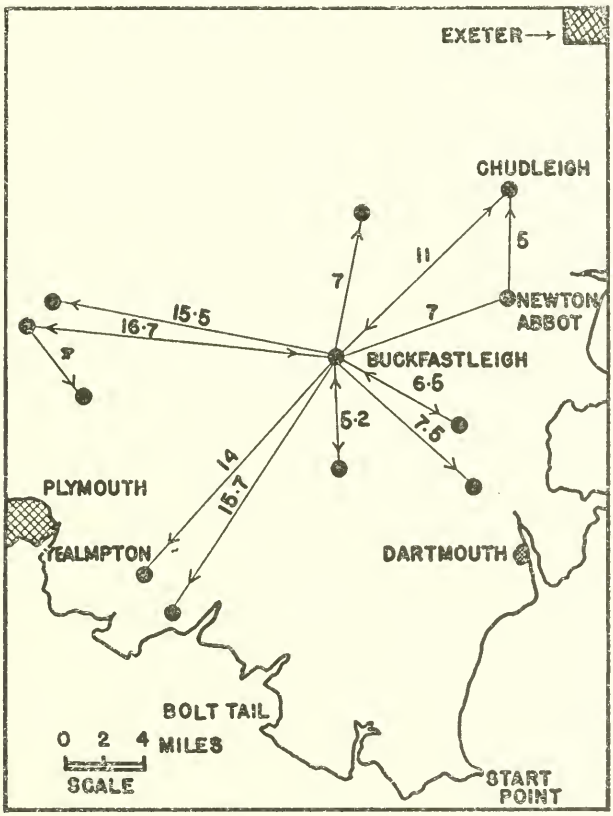


FIGURE 1.—Map illustrating typical movements of greater horseshoe bats in South Devon. Figures include mileages; arrows indicate directions of flights. (After J. H. D. Hooper; based on observations made by Mr. Hooper and members of the Devon Speleological Society.)

large parts of the population. In Australia, the forest areas where they hang up to sleep are known as camps, and flights of many thousands of bats pass from one camp to another on their journey to the extreme southeastern part of Australia where they spend the summer.

But the extent of these aerial migrations is surpassed by those of the mammals that live in the sea, the seals and the whales. The most spectacular migration among the seals is that of the fur seal that breeds on the Pribilof Islands. The islands lie 200 miles off the coast of Alaska north of the Aleutian Islands, and on them the fur seals haul out in almost incredible numbers every breeding season. The old bulls

arrive first and take up their territories; then the cows come and give birth to their pups a few days or even a few hours after their arrival. Each bull collects a harem of females over which he keeps watch, driving away any rivals that may try to poach on his territory. While the cows are nursing they go to sea to fish, and return every day or so to feed their pups, but the bulls remain at their posts for about 3 months without feeding. At the end of the season the old bulls move off to their winter quarters south of the Aleutians and in the Gulf of Alaska, but the cows, the pups, and the young bulls go much farther, and winter at sea as far south as the latitude of southern California, successfully making a journey of 3,000 miles across the open ocean and not by following the coastline. Many other kinds of seals, though not all, have similar migrations perhaps on a rather smaller scale, though as yet little is definitely known of them.

Many kinds of whales make regular seasonal migrations over great distances. In the southern oceans the gigantic blue whale, the fin whale, the humpback and others perform regular journeys during the antarctic summer, to the far south, where they feed upon the rich plankton that swarms in those cold seas at that time of year. And then they depart to the north, and spend the winter in temperate and subtropical seas, where they feed very little or not at all while their young are born and nursed through the early weeks of life. In these migratory journeys whales cover many thousands of miles far away from any land so that there is no possibility of obtaining any guidance by following the lines of a coast.

The migrations of the sea mammals thus differ from those of terrestrial ones, which are not only limited by topographical features of the land but might also be guided by the recognition of landmarks. The marine mammals can have no such influences to guide them on their journeys.

How then do they do it? Frankly, we just do not know; none of the many theories that have been put forward to explain such migrations seems to me to be adequate. People were once content to say "instinct" and leave it at that, but the expression was no more than a confession of ignorance. The invocation of the Coriolis force has been shown to be untenable as an explanation of the orientation of birds during migration [2]; it would be even less applicable to the more slowly moving migrating mammals.

Much thought has been given to the possibility that migrating birds navigate by observing the position of the sun or other heavenly bodies; if birds can navigate by that means, why not mammals? It seems to me that there has been some confusion of thought here. If an animal is to navigate successfully it must have a knowledge of where

[2] See Matthews, G. V. T., Direction-finding in birds, Discovery, May 1953, p. 149.

it is, and of where it is going—that is to say it must have some kind of geographical knowledge and some kind of mental image that corresponds to a map. If it had this knowledge, it is conceivable that the altitude of the sun might give it some rough idea of its latitude on its mental map. But it seems to me quite impossible that it would in any way be able to determine its longitude, however roughly. I do not suggest, of course, that an animal would have any conscious conception of these coordinates, but fixing a position on a map of any sort implies the use of them, even if it is unconscious. Furthermore, any suggestion of navigation implies the knowledge of a destination and of its approximate position; it seems to me very improbable that any animal can have that knowledge. And some animals that migrate singly and alone certainly cannot have it, for instance the young of some birds that migrate over routes they have never traveled, to places they have never visited, long after their parents have deserted them.

We know that some insects orientate themselves by the position of the sun, and that they can do so even when the sun is obscured by cloud because they are sensitive to the polarized light impinging on them. But this orientation serves only to take them to and fro between home and foraging grounds that they have discovered by random search; an experience, if not a knowledge, of both ends of the journey is implied, and the distances covered are furlongs at most, not thousands of miles. It seems to me improbable that migrating mammals can be guided by such means.

It is of course possible that migratory animals have some sense of direction that we have not. The way in which cats and dogs, and some kinds of birds, sometimes return to their homes over great distances after they have been removed in closed containers so that they can have no possible guidance from a memory of the route traveled, lends some support to this suggestion. If animals do have a perception that is lacking in ourselves, we can no more hope to understand it than a man blind from birth can understand what is meant by "color." But a sense of direction would presumably need some sense organ for the reception of stimuli of some sort—no animal can be aware of its environment, or even of itself, without the appropriate receptor organs. No such receptors are known to us. It is possible, but not probable, that animals do have receptors of this nature and that we do not recognize them—lacking that sense we overlook them.

Have we any remains of a sense of direction that might have been more highly developed in our remote ancestors? It seems improbable that we have any idea of direction if we are cut off from all visual or other perception of the route we have traveled. Of course, if you were carried blindfold to the middle of England and told to make your way across country to London you might succeed in hitting it off roughly

by noting the position of the sun, even if there were no signposts and no one to tell the way. But that would be because you carry a memory of the maps you have seen, and know that you are in England: if you were similarly placed in France, but thought you were in England, you would have considerable difficulty in finding your way until your knowledge of geography and topography showed you that you could not be in the country you thought. There seems to be no evidence at all that we have any inherent sense of direction apart from immediate experience of our surroundings. If animals have any such sense we do not share it.

There has been some discussion about the possibility that birds may be able to orientate themselves on migration in relation to the earth's magnetic field, that they have some sense organ that is effectively a compass. Some experiments were carried out with homing pigeons; small magnets were fixed to them to find out whether any effect could be produced thereby upon their homing abilities. The results were entirely negative, and moreover other experiments have shown that birds appear to orientate themselves according to the true points of the compass rather than the magnetic ones. It is improbable that mammals differ in this point.

We know, therefore, something of the facts about the migrations of some mammals, but the means whereby migration is carried out still remain completely unknown; many theories have been tried but none of them has been capable of experimental proof. It is all very puzzling; as far as we know the bodies of the other mammals are essentially similar to our own, and we flatter ourselves that our brains are more highly developed. And yet these animals that we classify as lower than ourselves can do something, and presumably with their brains too, that we cannot; something so far outside our own experience and abilities that we cannot even conceive how they do it. Natural selection has no doubt fixed the tendency to migrate in those species where it is found, but that does not explain how it is accomplished. There is obviously much more to be found out about the migration of animals than we have yet discovered.

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The Flight of Animals[1]

By James Gray

Fellow of King's College
Professor of Zoology in the University of Cambridge

[With 10 plates]

If a kangaroo, say, or a frog, or a flea, or any land-living animal is to lift its body off the ground at all and stay in the air even for a very short time, we know that it has to exert an intense muscular effort to do so. Then how can a bird rise so easily from the ground and stay in the air in flight for hours at a time?

Flight depends on wings. A wing, we might say, is a limb whose movement through the air produces forces that can counteract the downward pull of gravity and can also drive the body forward through the air. It has long been known that wings can do these things, and from time to time adventurous people have tried to design mechanical wings capable of lifting a man and carrying him along through the air. All these experiments failed; but in the end, for good or ill, they led on to the invention of airplanes. Men tried for a long time, by watching the birds, to learn how a man could fly; today, quite the opposite, we are trying to understand the flight of birds by applying principles which have emerged during the design of airplanes. The movements of birds' or insects' wings are extremely complicated, and it is easier to feel our way into the very difficult problem of animal flight by drawing a distinction between two kinds of flight—active flapping flight, and passive gliding flight.

We can start our inquiry, then, by comparing the motion of a soaring eagle with that of a "glider" airplane; in both, the wings are used as fixed and rigid surfaces, and neither glider nor eagle uses an internal engine or source of power. From the very start of our study we must realize that all flight—whether active or gliding—depends on forces set up between the wing and the surrounding air. In a vacuum, an airplane or a bird would fall to the ground just as rapidly as a stone.

[1] Reprinted by permission from "How Animals Move" (The Royal Institution Christmas Lectures 1951), published by the Cambridge University Press, Great Britain.

We must also understand that the air exerts a force against the wing only when there is movement between them—either by the wing moving through the air or by the air moving past the wing.

In its simplest form a wing can be thought of as a flat plate sticking out sideways from the body of a bird or from the fuselage of an airplane. If this flat plate be held edgewise in a current of air, the force of the current will tend to drag the plate with it downstream; and only an external force tending to pull it upstream can hold it in position. If, however, we slightly raise the edge that faces upstream (or

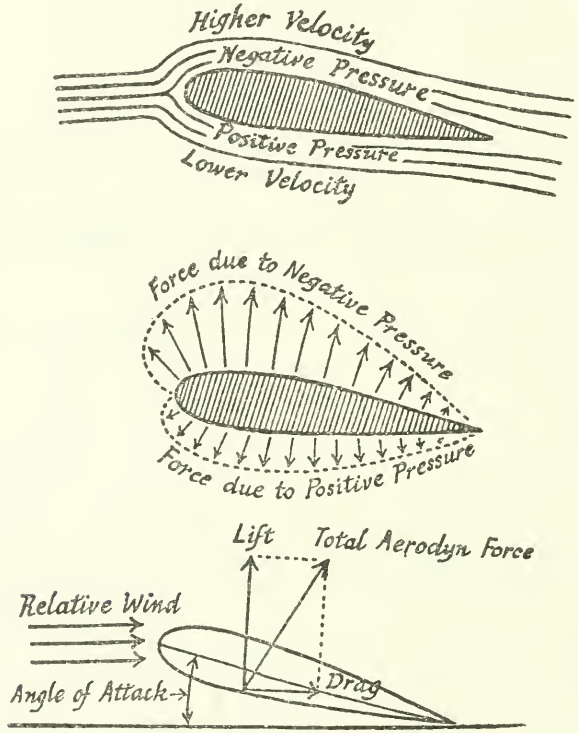


FIGURE 1.—When a wing is held at a slight angle to an air current the air flows faster over the upper surface than the lower, thereby creating suction above the wing and pressure below the wing; the suction and pressure together cause the "lift." At the same time the moving air tends to "drag" the wing backward. The total effect is to lift the wing and drag it backward.

lower the downstream edge) the plate will tend to rise bodily in the air, although, at the same time, the force tending to drag it along downstream increases. The moving air is thus exerting two forces on the inclined plate (fig. 1): (1) a lift force tending to raise the plate; and (2) a drag force pushing it back in the direction of the air stream. True gliding flight becomes possible when these two forces are so adjusted as to be exactly equal to the weight of the bird or airplane.

Tests with various sizes and shapes of wings, in winds of various speeds, have shown that the lifting effect of the air depends on four main factors: the shape of the wing; its size; the angle at which it is inclined to the direction of the wind; and the speed at which the wind is traveling past it.

The mechanical efficiency of a wing depends largely on its ability to develop a large lifting force for a relatively small increase in backward drag; but, from a practical point of view, the ability to fly depends on the extent to which the exact balance can be maintained between the lift and drag forces of the air on the one hand, and the pull of gravity on the other. Stable, continuous flight can happen only when the wings are so arranged that any slight accidental disturbance of the airflow is automatically compensated.

We can see these principles in action when a thin sheet of light wood or a card is released in the air. A uniform sheet glides for a short time toward one side, then changes its direction of motion and falls to the ground like a falling leaf. But if a small lead weight is attached to the leading edge, the sheet glides smoothly downward when the size of the weight is so adjusted as to bring the center of gravity of the whole wing to a point about twice as far from the trailing edge as it is from the leading edge. We can, with a little practice, get the same result—a smooth glide downward—by shaping the card itself into the outline of a bird with outstretched wings and tail.

We have now reached a point at which we can say that an animal can fly, provided it keeps its wings moving through the air in such a way as to ensure that the lift and drag forces exerted by the air against the body all combine to form an upward force equal to the animal's weight and acting through the center of gravity of its body. Now let us look at some of Nature's gliders.

Broadly speaking, gliding animals may be separated into two classes: those that get themselves the necessary motion through the air by their own muscular efforts beforehand, and those that keep themselves moving by falling under gravity. A flying fish (*Exocoetus cypsilurus*) is a good example of the first kind. What is noticeable about a flying fish is the enormous size of its pectoral fins. When a flying fish is swimming it keeps those fins furled against its sides, but spreads them wide as it leaves the water. Before the takeoff the fish drives itself slantingly upward to the surface by vigorously swimming with its tail; as it leaves the water its pectoral fins (and sometimes also the pelvic fins) are spread, and the fish finds itself airborne just above the surface of the sea (pl. 1).

According to most observers, flight seldom lasts for more than 1 or 2 seconds and the distance traveled in that time varies from 10–50 meters. From time to time the fish may regain flying speed by beating

its tail against the water, although the rest of its body remains in the air. There is, however, some evidence to suggest that much longer flights may occur, lasting for 10–12 seconds and covering perhaps 400 meters without touching the water. All observers agree that the fish does not move its pectoral fins in flight, though they may vibrate passively as it speeds through the air. About these flights we have much to learn, and exact observation is difficult, but there seems little doubt that ordinary flights of 1 or 2 seconds and of 50 meters or less are maintained by the kinetic energy (the energy of speed) given to the body in swimming by the tail striking against the water before the fish is airborne.

The combined lift and drag of the body at various speeds of airflow has been measured in a wind tunnel, and although such observations are not yet altogether satisfactory, they suggest that flight could be sustained for about 6 seconds and over a distance of 200 feet, if the takeoff speed were something like 30–35 miles per hour. This speed seems very high compared with that of other fishes, but it may be that when the body of the fish is in air and only the tail is in water these higher takeoff speeds could be reached. Still, it is difficult to believe that the takeoff speed could ever be great enough for the fish to fly for 10 or 12 seconds and for distances of 400 meters. If such flights really occur, as they are said to do, we can only assume that the fish is able to draw on some source of energy other than that given to it (when it is in the water) by its tail. It may be that unusual air conditions near the surface of the waves make longer flights possible; but all we can say at present is that long-sustained flights offer an interesting and difficult problem.

For the time being, however, we can look upon the normal short flight of the flying fish as a typical example of velocity gliding: the fish stores kinetic energy in its body by swimming—by moving its tail in water—and expends this energy when it is airborne in overcoming the drag effect of the air, gaining thereby lift enough to overcome gravity. And after all, this is not so very different from the flight of a small bird, where periods of passive glide occur between periods of active wing beats.

One member of the frog family is a glider—the only one, so far as is known. This frog (*Rhacophorus*) was discovered in Borneo about a hundred years ago, by a Chinese workman employed by the naturalist Alfred Russel Wallace. The Chinese assured Wallace that "it came down, in a slanting direction, from a high tree." Wallace noted that the surface of the very large webbed feet was considerably larger than that of the body, and there can be little doubt that these frogs do launch themselves from trees to glide down to a point 30 or 40 yards from where they started. The webbed feet and the under surface of the body act together as a wing, and the energy required to

drive the animal along in the air comes from gravity in a way which we shall consider later.

Among living reptiles, only one rather doubtful glider is known—the so-called flying dragon (*Draco volens*). This odd lizard has a flexible membrane down each side of its body, and it is said to glide, like the flying frog, by jumping off trees. It seems strange that there are no other living flying reptiles, when one remembers the great pterodactyls of prehistoric times. Pterodactyls (meaning wing-fingers) had enormously enlarged fourth fingers from which membranes spread across to the body and hind legs: their wings sometimes had a span of 20 feet (fig. 2). If you want to imagine what they looked



FIGURE 2.—The pterodactyl, showing the enormously enlarged fourth fingers, with membranes extending to the body and hindlegs to form wings.

like you cannot do better than read Conan Doyle's "Lost World." Unlike birds, pterodactyls had poorly developed breast muscles; active flapping flight must have been impossible; how these gliding monsters launched themselves, either from trees or from the tops of steep cliffs, we do not know.

And now we come to the greatest of all flying animals, the birds. The mastery of birds over air is incomparably greater than that of any other group of animals, and we shall have to examine them in

detail a little later. Here we need only note that a bird's front limbs have been completely specialized for flight; each wing forms a structure of peculiar beauty and complexity (pl. 4, fig. 1). Unlike that of any other flying animal, the wing surface in a bird is made up of feathers, all fitting together to form an efficient lifting surface and yet capable of being neatly furled when not in use. There are two chief kinds of gliding birds: the low gliders, such as shearwaters and albatrosses; and the high soarers, such as eagles and vultures.

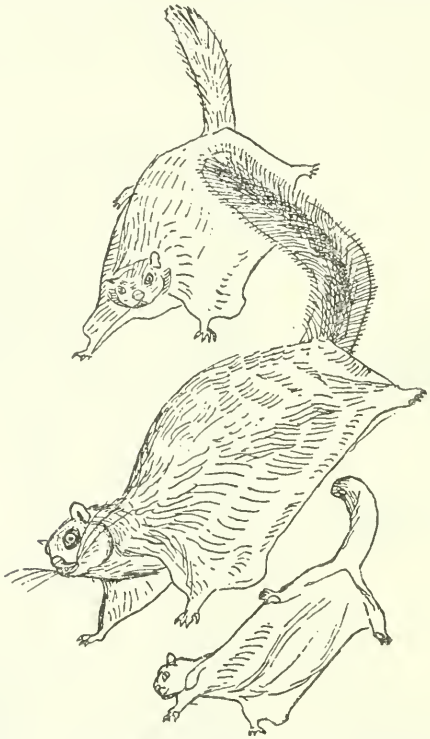


FIGURE 3.—The flying squirrel (*Glaucomys*), showing its gliding flight with limbs outstretched.

Of mammals, the best known gliders are the bats. A bat's wing surface is probably not unlike that of a pterodactyl, but instead of spreading from the fourth finger only, it is spread between the body and all the fingers of the hand except the thumb. A bat's flight is not very different from a bird's flight; but it differs in this, that bats normally rest by day and fly by night. How they do this we shall see later on.

There are also a number of mammals capable of gliding from tree to tree: flying phalangers, flying squarrels; all of these have membranes of some kind running between their wrists, body, and back legs. When such an animal is walking, the membrane is slack, but when it takes to the air for a glide, the front and hind limbs are spreadeagled,

stretching the membrane out into a taut and effective wing (pl. 4, fig. 2, and text fig. 3). All these animals live in trees; they climb a tree, and from there, launching themselves into the air, glide gracefully down, often rising toward the end of their flight and landing on a neighboring tree trunk or branch.

All the flying animals we have examined so far have solved the problem of gliding flight only to the extent of being able to stay in the air for a few seconds. How do some birds glide or soar as they do for many minutes or even hours at a time?

Let us start with the type of glide seen when a pheasant or a gull is approaching the ground; the wings are stiffly stretched out and the bird is slowly losing height all the time. Its speed through the air is being maintained by the accelerating effect of gravity, and its motion can be likened to that of a sled traveling down a slope. On a slope, the weight of a sled acts partly down along the slope, and partly downward at right angles to the slope; the force acting downward at right angles is met by an equal but opposite reaction from the slope itself, but the force acting down along the slope speeds up the sled and overcomes the friction between the runners and the slope. Call the force acting down the slope the driving force, and the force acting at right angles to the slope the sinking force. How much bigger or smaller one of these two forces is than the other depends, of course, on the angle of the slope.

We can apply this picture to a gliding pheasant if we imagine each of its wings to rest on a smooth rigid runner sloping downward toward the earth (fig. 4); as with the sled, the weight of the bird would give a driving component and a sinking component. As the bird began to slide down the runners, the motion of its stiff wings through the air would induce lifting forces against the wings, and because of this the passive reaction from the rigid runners would decrease; at the same time, the wings and body would be subjected to a drag force acting along the line of the runners in a direction opposite to that of the driving force of gravity. As the speed of glide increased, the lift would also increase, until a time would come when the lift is equal to the sinking force of gravity, and the drag force is equal to the driving component. At this moment we might take away the rigid runners without making any difference at all to the bird: it would go on gliding through the air at constant speed.

A good glider travels a long way horizontally with the smallest possible loss of height, and you can judge how good it is as a glider by measuring the angle between the track of its motion and the level horizon. It is very important to know that this angle does not depend on the weight of the bird; it depends solely on the ratio of the forces—the lift force to the drag force—exerted by the air; that is, it depends on the shape of the wings and on the angle which the surface of the

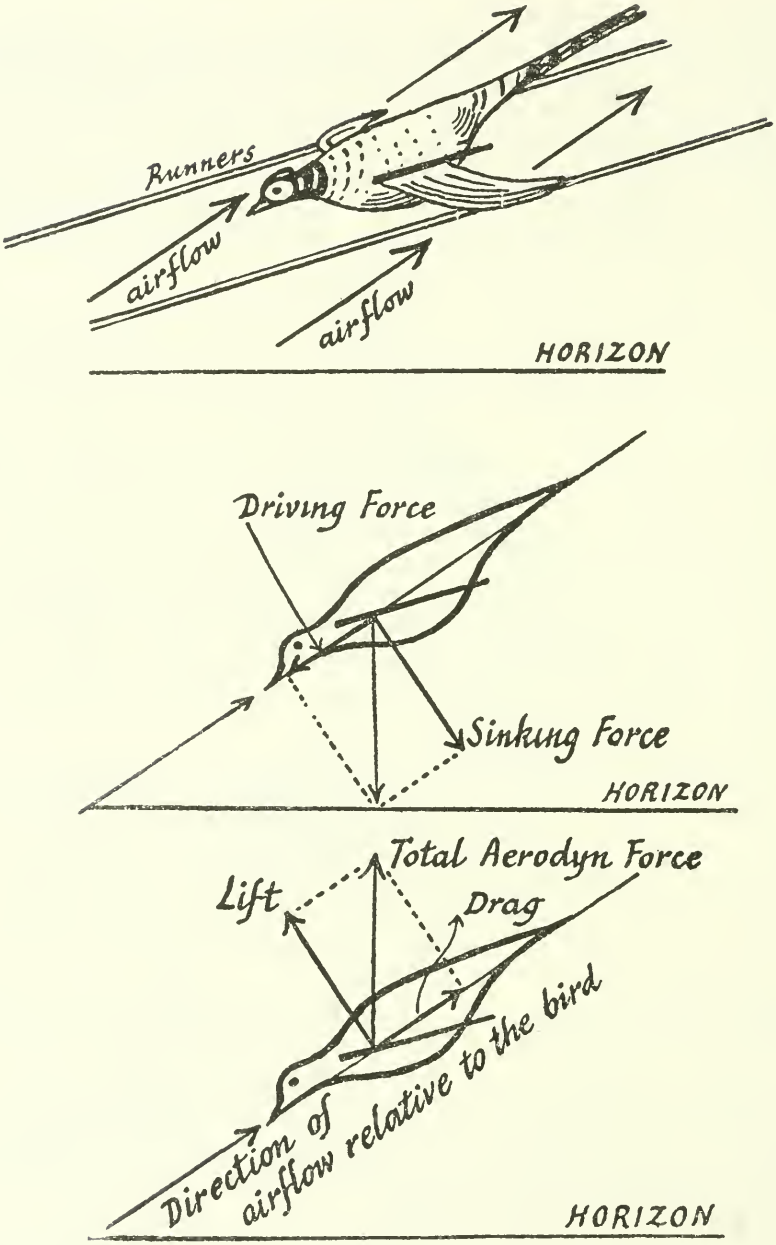
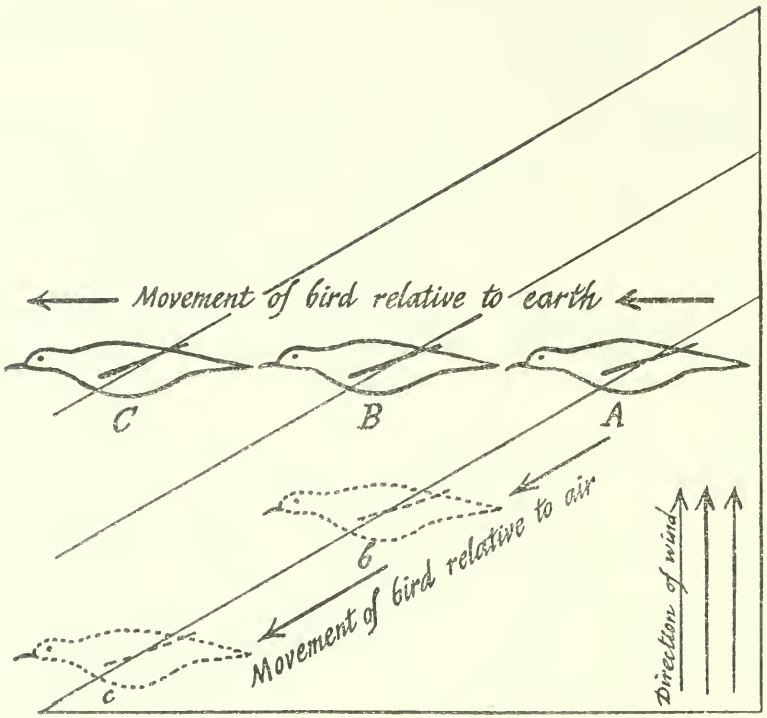


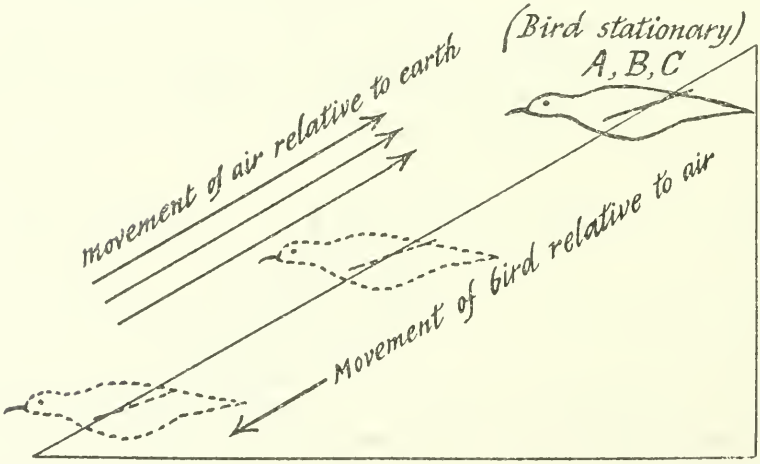
FIGURE 4.—When gliding steadily in still air the forces (lift and drag) exerted by the air against the bird are exactly equal but opposite to the weight of the animal. The conditions are comparable with those which would exist if a bird were sliding down a pair of rigid runners in a vacuum: the reaction from the runners at right angles to their surface would be equivalent to the lift of the wing and the friction of the runners to the drag of the bird's body.

wings makes with its own direction of motion. The speed of the glide, on the other hand, depends partly on the weight of the bird and partly on the size of the wings. A heavy bird with small wings for its size glides rapidly; a light bird with large wings glides slowly.

The distance that can be traveled by a bird when it is gliding through still air under its own weight is, of course, limited by the height from which the bird starts—sooner or later it must reach earth and the glide will come to an end. But if the air is not still, but is itself moving over the earth, the story is very different. The lift and drag forces exerted by the wings depend solely on the particular motion of the wings through air; if the air itself is moving, the motion of the bird relative to the earth is the resultant of these two motions: the motion of the bird through the air, and the motion of the air itself over the ground. For example, if a bird is gliding down an air slope losing vertical height at a rate of 5 feet per second, and the air itself at the same time is rising from the ground at 5 feet per second, then the bird will glide along level above the ground, although it is all the time traveling downward through the rising air (fig. 5). And if the air is rising from the ground faster than the bird is losing height through the air, the bird will keep on getting higher above the ground although it makes no wing movement to do so. A horizontal wind cannot affect the rate at which a bird loses height above the earth—such a wind affects only the rate at which the bird moves along horizontally over the ground during its fall. What will happen then, when the wind is blowing backward and upward at exactly the same speeds as a bird is moving forward and downward along its cushion of air? Seen from the ground then, the bird remains fixed in space (fig. 6). In such conditions a bird is not unlike a man who is walking down a moving stairway at the same speed as the stairway itself is moving upward.

The extent to which upward currents of air may account for the behavior of gliding birds can be judged by watching birds at flight in regions where upward air currents are known to exist. There are two main causes of upward air currents: first, when a horizontal wind meets an obstruction and is deflected upward; and second, where air, warmed by the surface of the earth, moves upward and is replaced by colder air from high levels of the atmosphere. Typical cases of gliding on upcurrents caused by obstructions may be seen when swifts glide along the eaves on the windward side of a building; or when gulls glide up and down a line of cliffs when the wind is blowing onshore; or when eagles and buzzards glide on the windward side of mountains. When a strong headwind is deflected upward by a mountainside, buzzards may hang on the air, fixed in space high above the earth for surprising lengths of time.





FIGURES 5 (upper) and 6.—When gliding in still air a bird is constantly losing height relative to the ground, but if the air is rising from the ground as fast as the bird is falling, it is able to glide along a horizontal path for an indefinite period (fig. 5). If the air is moving backward and upward from the ground at the same speed as the bird is traveling forward and downward, the bird can hover with motionless wings, quite stationary to an observer on the ground (fig. 6).

In temperate climates the use of thermal upcurrents by gliding birds is somewhat restricted; nevertheless, birds may sometimes gain considerable height over towns or other regions where warm air is rising. In tropical countries, however, cheels, vultures, and birds of this sort, are very good at this kind of glide (fig. 7). During the mornings, in these places, columns of warm air rise from the ground and drift downwind. The birds appear to glide down a spiral within such a column of air, and as the rate of their downward movement is less than the rate at which the column itself is moving upward, the birds constantly spiral upward, getting higher above the earth as they drift downwind. As we might expect, thermal gliding is characteristic of birds with light bodies and large wings. On these two factors (weight and wing surface), depends the speed at which the bird would lose height when gliding in still air and, consequently, the speed at which the air must rise if the bird maintains a horizontal or upward path.

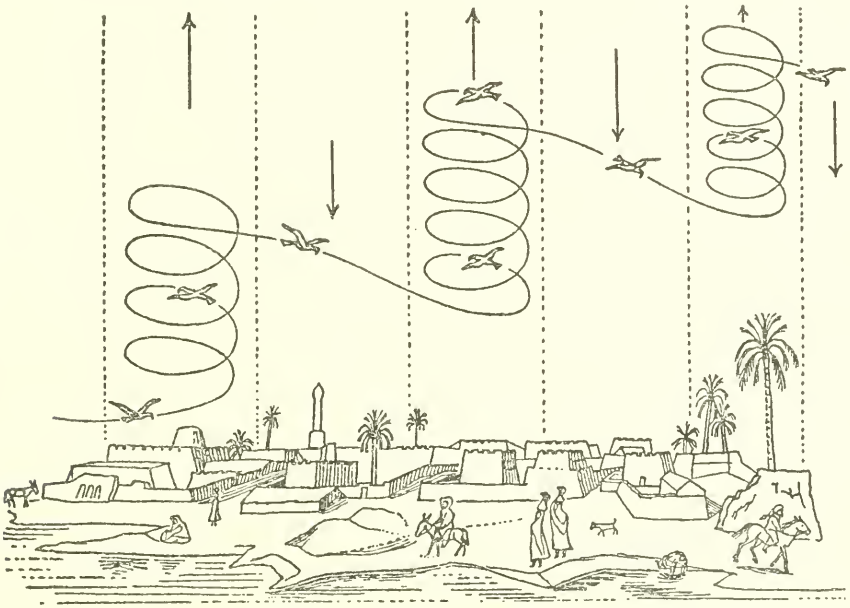


FIGURE 7.—In regions where upward currents of warm air alternate with downward currents of cool air, birds can glide upward in the former and downward in the latter. Arrows show direction of air movement. It is seen that a bird can gain considerable height by taking advantage of these air currents.

So far, the principles we have applied to gliding birds are exactly the same as those made use of by a glider pilot, whose powers of gliding and of staying in the air depend almost entirely upon the use of obstructional and thermal upcurrents. Certain birds, however, are able to glide in conditions where there seem to be no upcurrents: shearwaters and albatrosses, for instance, glide near the surface of the sea,

though how they do so no one has yet managed to explain. Physical research may one day show us that upcurrents of air arise near the leading surfaces of traveling waves, and that the surface gliders are able to use these currents. Or it may be that these birds have solved the problem of gust flying—gaining height when they meet a gust, and losing height again as the gust dies away, rather as a tennis ball can be kept in the air by a succession of small upward hits from a racquet.

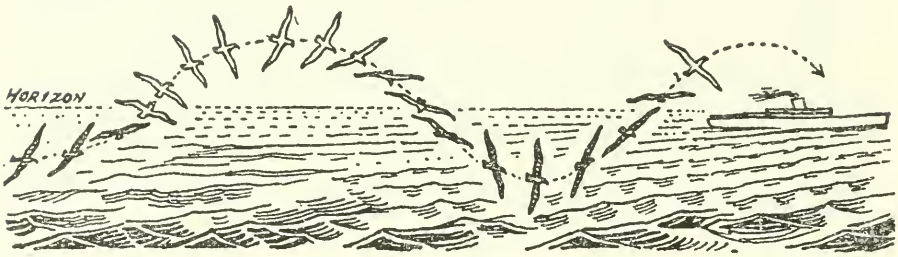


FIGURE 8.—The flight of the albatross. Note how the bird makes semicircular turns, climbing into the wind and descending.

All observers agree that an albatross cannot maintain its gliding flight if there is no wind. These great birds seem to rise in a slanting direction against the wind to a height of about 20 feet, depending on the strength and direction of the wind; this climb is followed by a wide semicircular turn as the albatross rapidly descends downwind; and then the cycle is repeated (fig. 8). As the bird turns into the wind again, its speed relative to the air has been increased and the kinetic energy (energy due to movement) thus gained can be used for gaining height; this results in a gain in potential energy (energy due to height) which is then available for maintaining the bird's flight downwind; and so it goes on. Notice that this interpretation of the flight of the albatross depends on the existence of an adequate difference between the wind speed at the surface of the sea, and that at a level perhaps 20 feet up.

Gulls behind a steamer give us an example of gliding that is by no means as simple as it may appear. No doubt there is an upward deflection of air by the hull of a ship, and the heating effect of the vessel's smoke stacks may cause certain upward thermal currents, but there is also a mass of air, stationary in relation to the ship, and therefore traveling over the sea at the same speed as the ship. How far the gulls rely on the upcurrents, and how far they glide down in the stationary air, would form an interesting subject of study.

Stability in flight is of the greatest importance in an airplane; it must be designed so that any slight disturbance in balance between lift, drag, and weight is automatically and immediately corrected,

yet all the conditions of balance must also be under the command of the pilot, for by control of these he must fly, and fly as he decides to.

Similar problems must be solved by birds. A bird achieves control partly by using the tail as a horizontal rudder, and partly by changing the shape and posture of the wings; and these movements are also under the immediate control of the semicircular canals of the bird's ears, just as are the movements of the fins of a fish.

A bird flying—propelling itself by its own muscular efforts—is one of Nature's great masterpieces, and she guards very closely the secrets of her success. It is easy to see that the bird's wings are beating upward and downward and to realize that these movements must provide a lifting force equal to the weight of the body, and a forward thrust equal to the backward drag of the air. From a mechanical point of view, the wings of the flying bird are carrying out simultaneously the functions performed respectively by the wings and the propeller blades of an airplane; a bird's wings are, therefore, more closely comparable with the rotor and screw blades of an autogyro or helicopter.

But any attempt to make an accurate study of the movements of a flying bird meets with difficulties. The form of the wing, for instance, is constantly altering during the course of its beat, some of the changes being due to the suppleness of the wing feathers and others to the bird's own internal muscular movement. Then again, the bird's speed and the frequency of its wing beats are too great for the wing to be exactly observed by the human eye. As a general rule, the smaller the bird the faster and more often it beats its wing; a swan or a heron beats its wings about 2 times, a gull 5 times, a pigeon 10 times, and a hummingbird 50 times per second. Details of such wing movements can only be found out by high-speed cinematography using a special light that gives a succession of very bright and very quick flashes. The photographs shown on plates 5–8 were taken in this way; they show the movement of the wings of a pigeon flying slowly across a room.

In plates 5 and 6 a pigeon is flying toward the camera. The downstroke begins as shown by photograph 1 with the wings fully extended, stretched up over the back of the bird. Both wings then strike downward (photographs 2–4) with the whole surface of the wing moving down almost at right angles to its horizontal path of motion; the primary feathers are bending upward under the pressure of the air (photograph 3). When the wings have reached a horizontal position (photograph 4), the downward motions cease and the wings swing forward, to meet in front of the body (photographs 5 and 6); during this change of movement the primary feathers separate from each other, and bend sharply upward under the lifting effect of the air moving between them. Photograph 7 shows

the end of the downward and forward stroke of the beat. The backward and upward stroke starts with an upward and backward movement of the wrist joint, uncovering the head and leaving the primary feathers directed forward along the line of flight (photograph 8). Then the primary feathers are drawn violently backward and upward (photographs 9–11) and the whole wing straightens out in position for a new downward movement.

These same phases of a complete wing beat can also be seen from another direction in plates 7 and 8, where the pigeon is flying across the field of the camera; photographs 1–6 show the downward and forward stroke, and photographs 7–12 show the upward and backward stroke. Photographs 2–4 show the separation and bending of the primary feathers during the first moments of the downstroke, and the forward swing of the whole wing is seen in photograph 6. The raising of the wrist and the subsequent very rapid backward flick of the wrist and primary feathers are seen in photographs 8–11. From these photographs it is possible to draw three conclusions with fair certainty: (1) During the initial downward wing movement the wing surfaces are traveling down in a direction almost perpendicular to their path of motion, and consequently elicit a powerful upward reaction from the air. (2) During the second part of the downstroke the wing is traveling forward with its surface inclined to the path of motion at a relatively small angle; it thus acts as an airfoil and develops a lift in the normal way. (3) The main propulsive thrust comes from the rapid backward movement of the primary feathers, which occurs during the upward stroke. Supposing this analysis to be true, it may be said that the downstroke of the wing gives the lift and the upstroke produces both lift and forward thrust.

But can a bird's wing do so much, and do it constantly, without getting tired? The downstroke is easy, for the wing is pulled downward by the very large *pectoralis major* muscle; but the muscles that move the wrist and raise the wing are small by comparison, and it is difficult to see how a very rapid series of upstrokes could be kept up. And, in fact, it cannot. The photographs shown in plates 5–8 were taken during slow short flights of about 20 feet, and it soon appeared that pigeons find such flights tiring; 8 or 9 flights left this bird disinclined to take further part in the experiment. It seems likely, therefore, that the wing movements observed during and immediately after a takeoff from the ground are not the same as those of a pigeon in full sustained flight in the open air, for we know that such birds can in fact travel for a long time without showing fatigue. Dr. R. H. J. Brown, therefore, decided to photograph the bird in full flight down a long corridor. A series of such photographs is seen in plates 9 and 10. Two main changes are to be noticed in the downstroke: (1) the amplitude of the beat is smaller—the wings no longer rise high enough

to meet over the bird's back; and (2) they no longer swing forward at the end of their downward movement: the bird's head remains clearly in sight at all stages of the flight. Changes also occur in the upstroke; the backward flick of the wrist and primary feathers has almost, if not completely, disappeared: the inner surface (radio-ulnar) of the wing begins to rise first and is followed by the wrist and primaries. What these characteristic features of open flight may signify is not altogether clear. During the downstroke, the whole wing travels downward and forward at a relatively small angle to its path of motion, and it seems likely that the resultant "lift" is directed both forward and upward, and can therefore propel the bird as well as support its weight. On the other hand, the upstroke of a bird in full flight appears to be of a more passive kind than the upstroke immediately after a takeoff; perhaps during free flight the wing is passively raised by the pressure of air against its under surface, and its

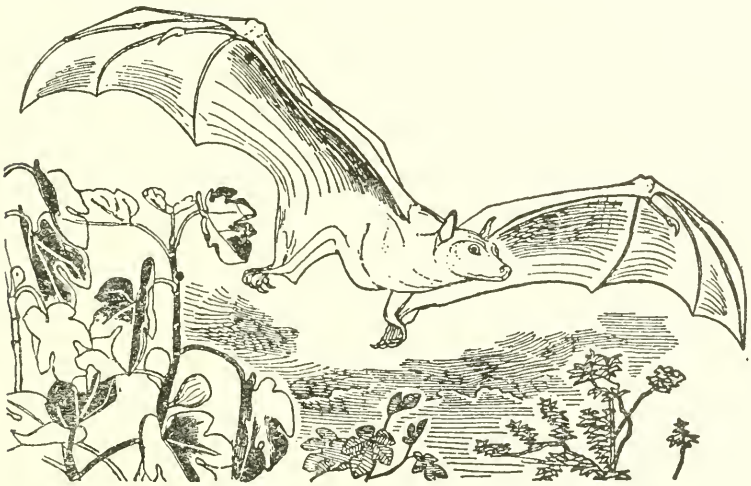


FIGURE 9.—A bat in flight. The wing action is similar to that of a bird.

rate of upward movement controlled by the braking effect of the *pectoralis major* muscle. If this is so, the wings, during the upward stroke, act as kites to lift the body merely at the expense of some diminution of forward speed—rather like an umbrella opened downwind on a windy day. Whether this suggestion will bear further scrutiny remains to be seen, but at least it seems to explain one way by which rapid free flight can be made much less tiring than a takeoff from the ground—for if our explanation is correct, the relatively small *pectoralis minor* muscle would be in action only for a little while after each takeoff. After that the only muscle concerned would be the large *pectoralis major*.

Among vertebrate animals there is only one other—the bat (fig. 9)—whose powers of flight come anywhere near those of a bird. At pres-

ent, we know little about the movements of a bat's wings, but as far as we can see, the motion of the bat's wings appears to be similar to the motion of a bird's wings, and it seems likely that the same general principles would apply to both (pl. 2, right). What is characteristic of a bat's flight is, however, its ability to avoid obstacles when flying in the dark. At one time this very useful faculty was believed to be due to sense organs on the wings capable of registering the slight alterations in air pressure which must follow when the moving wing came too close to some such solid obstacle. It has been known, however, for many years that a deaf bat frequently collides with obstacles. It has now been discovered that the vocal chords of a bat can give out sound waves of very high frequency, far higher than those to which a human ear can respond: these waves—not to be confused with the squeak of bats which some people can hear—are of 30,000–50,000 vibrations per second, and there can be little doubt that a flying bat sends out these supersonic waves and listens to their reflection from surrounding objects. In effect, the bats have evolved a very efficient echo-sounding equipment. We can make a model of such a system. A Galton whistle capable of sending out sound waves at 50,000 cycles per second, is mounted underneath (but shielded from) a telephone capable of responding to waves of this frequency. Then, if no obstacle lies in the path of the whistle's outgoing high waves, the telephone will not respond. But if any object is present that can reflect sound, the outgoing waves will be reflected back and picked up by the telephone where they can be made audible to an observer by means of an instrument reducing their frequency to a level to which human ears will respond. A model of this kind will instantly detect the presence of a glass window.

Among the invertebrates, only insects appear to have solved the problem of sustaining themselves in the air by means of wings. In most cases, a lift equal to the weight of the insect's body develops only when the wings are forced through the air by the insect's own muscular effort; the red admiral butterfly is one of the few insects capable of gliding flight. As with birds, the smaller the insect the more frequently does it beat its wings. A swallowtail butterfly beats about 5 times, a hive bee or a horsefly about 200 times per second. The record, so far as is known, is held by the males of a small midge (*Fercepomyia*) whose wings vibrate more than 1,000 times per second and produce a very high-pitched note. Muscular activity of this order requires a great deal of energy, and most insects can only maintain active flight if they are reasonably warm and supplied with plenty of food. We can measure the "fuel" (or food) requirements by allowing a small fruit fly (*Drosophila*) to beat its wings until all the food reserves in its body are exhausted: this will be after 2–4 hours of flight, according to the age of the fly. Flies wearied in this way

can resume flight about 30 seconds after being given a drink of sugar solution. Sustained flight is possible as long as the fly is provided with 3–10 milligrams of sugar per minute.

For an insect to fly along a level path, its wings must move in such a way as to exert a downward and backward thrust against the air; as the insect moves levelly forward, the air is driven downward and backward. We can see the air moving in this way in plate 2, left. The fly is photographed from one side against a dark background. The wings are vibrating, and catch the light at the top and bottom of their beat, and while the wings are beating, a shower of very fine lycopodium particles is allowed to fall on the fly from above and a photograph of $\frac{1}{25}$-second exposure is taken. The path traveled by a particle in this short time is shown as a white streak in the photograph, and the length of these streaks gives the speed at which the particle is moving. You will see in the photograph that they enter from above the zone of the wings at a relatively slow rate, and are forced backward and downward out of this zone at a much higher speed (in this particular case about 6 ft. per sec.). An insect's wings, as a free-flying bird's wings, do the work, at one and the same time, of propeller and wings of an airplane.

An ordinary house fly weighs about 14 milligrams or about $\frac{1}{2000}$ ounce, and a force equal but opposite to this weight represents the "lift" derived from the wings during level flight, while the backward component exerted by the wings against the air is equal but opposite to the drag encountered by the fly as it moves forward through the air. Some of the ways in which these forces are kept in balance with the weight of the body are being investigated by Dr. Hollick at Cambridge by means of a very ingenious and very delicate balance. This consists essentially of a very thin glass rod fixed firmly at one end so that it extends horizontally. The fly is mounted at the unfixed end of this rod, and any horizontal backward thrust developed by the fly causes the rod to bend to one side, and any lift force causes the rod to bend up. The magnitude of the forces can be determined by measuring the amount to which the rod bends sideways and upward. Any movement of the rod is detected by the reflection of light from two small mirrors attached to the rod, which reflect light onto a graduated scale.

As with a bird, the flight of a fly must be stable in the sense that accidental disturbances in the balance of lift, drag, and weight must be quickly or automatically corrected. Precisely how this is done is not known, but it is quite clear that insects possess special sense organs which inform the brain of changes in direction of motion of its body. Grasshoppers have special hairs on their heads, and it is the feel of the air as it flows past these hairs that enables the insect to keep its head facing into the direction of its flight. Dr. J. W. S. Pringle has investigated a particularly interesting organ of

direction control which exists in the two-winged insects (Diptera) or flies. In these insects the two hinder wings are replaced by two small knobs or "halteres" united to the body by stalks (fig. 10). During flight the tips of the halteres swing to and fro in the arc of a circle. When the fly is turned off its course, the halteres continue to swing

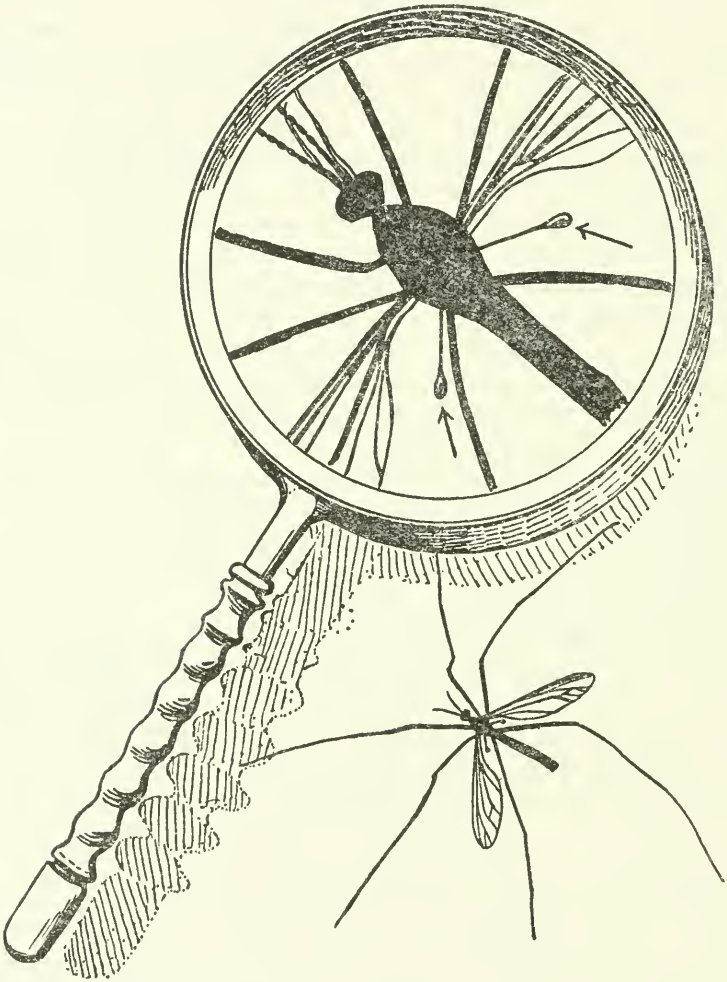


FIGURE 10.—The hind wings of flies are modified into club-shaped structures known as halteres (indicated by arrows). The halteres vibrate up and down and act as two-dimensional gyroscopes, enabling the animal to fly along a steady path.

in the same plane as before the turn, on the principle of a gyroscope, and the base of the haltere stalk is consequently twisted. This twisting excites a nerve, and the brain thereupon sends appropriate instructions to the muscles that control the wings.

By this time you will know something about how birds take to the air and how birds, bats, and insects maintain their flight. When the

flight ends, how do they return to earth? Airplanes, as you know, must be able to land as well as to fly, and so must flying animals. Legs are the landing carriages of flying animals; as the flier comes in to its landing place its legs are brought into position ready to take over the weight of the body. At the same time it is necessary for the forward motion of the flying body to be brought to an end at the moment of landing. Watch birds alighting and you will soon see clearly the whole process. In free flight they carry their legs out of the way—usually stretched out behind them; but as a bird comes in to land the legs are lowered so as to be there to take the weight at contact. At the same time, the wings are tilted backward, thus reducing the lift and greatly increasing the drag force exerted by the air. Almost as soon as the bird's feet touch ground, the wings furl neatly at the sides of the body. The movements of wings and feet are beautifully coordinated—not only at landing but also at taking off —for the spread and beat of the wings is associated in some way with any reduction of pressure between the feet and the foothold. This can be easily demonstrated by suddenly lowering the perch on which a bird, such as an owl, is standing: the wings immediately expand and beat downward.

The legs and wings of insects are related in an equally striking way. If the back of a fly is fixed by a small drop of wax to a fine glass rod, the wings will remain at rest so long as the legs of the fly are allowed to rest on some firm object. If this object is withdrawn the wings often begin to beat at once (and will always do so if a current of air is blown against the fly's body), and when the wings beat the hind legs are drawn up and back and the front legs are held out in front, so as to leave free a zone for the beating wings.

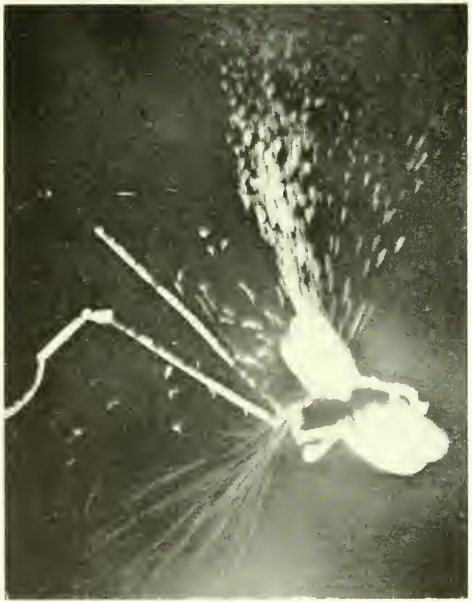
And now we come to the end of our story. I have tried to tell you how some of our commoner animals move and how they obey the same fundamental laws as those which govern the movements of inanimate things. The picture I have given is necessarily brief and incomplete, but it may, I hope, help you to look at moving animals with greater interest and understanding than in the past, and perhaps encourage you to make observations of your own. The more we learn about living animals, the more beautiful their activities appear; and in a world as much concerned as man's world is with ugly engines of destruction, the concept of natural beauty provides welcome relief.

PLATES





Flyingfish. The upper figure shows the fish "taking off" by beating its tail against the water. The lower figure shows the fish in full flight. (Photographs by H. E. Edgerton.)





Left: In order to demonstrate the propulsive and lifting effect of a fly's wings, the insect was photographed when its wings were beating in a shower of fine particles. In the developed photograph the particles appeared as lines whose length showed the distance traveled by the particles during the time of exposure of the photograph. Notice how the particles are drawn slowly toward the wing region and then projected very rapidly downward and backward. The reaction from this downward and backward current of air drives the fly upward and forward. (Photograph by Hollick.)

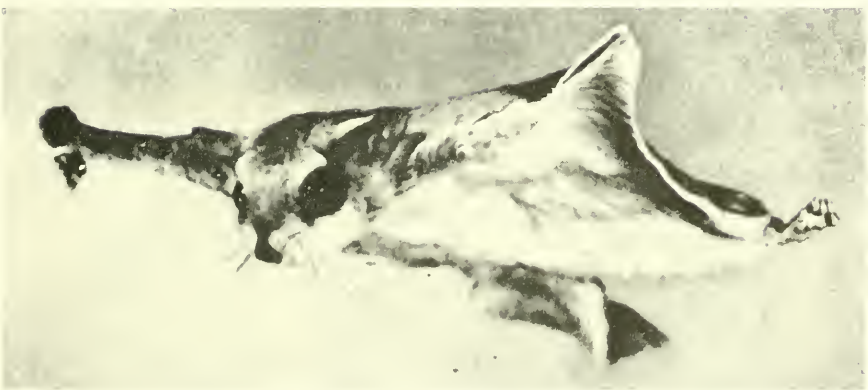
Right: A bat can avoid obstacles in the dark. The photograph was taken just as the animal was passing between two vertical wires almost as close together as the width of the animal's wing span. (Reproduced by special permission of the National Geographic Magazine.)



A bat in gliding flight. (Photograph courtesy National Geographic Magazine.)



1. A gannet in gliding flight. (Photograph by Dr. H. B. Cott.)



2. The flying squirrel (*Glaucomys*) jumps off trees and, spreading its arms and legs, glides downward gracefully for about 50 yards. (Photograph courtesy National Geographic Magazine.)



(See legend on plate 6.)

Plates 5 and 6, photographs taken at about 1/80-second intervals of a pigeon flying slowly toward a camera. Note how the wings beat downward and then forward until they meet in front of the bird's head. They then strike backward and upward.

(See legend on plate 8.)

Plates 7 and 8, photographs of a pigeon flying slowly across the field of the camera. Note how the wrists are raised at the beginning of the upstroke and how the primary feathers then strike rapidly backward and upward.

(See legend on plate 10.)

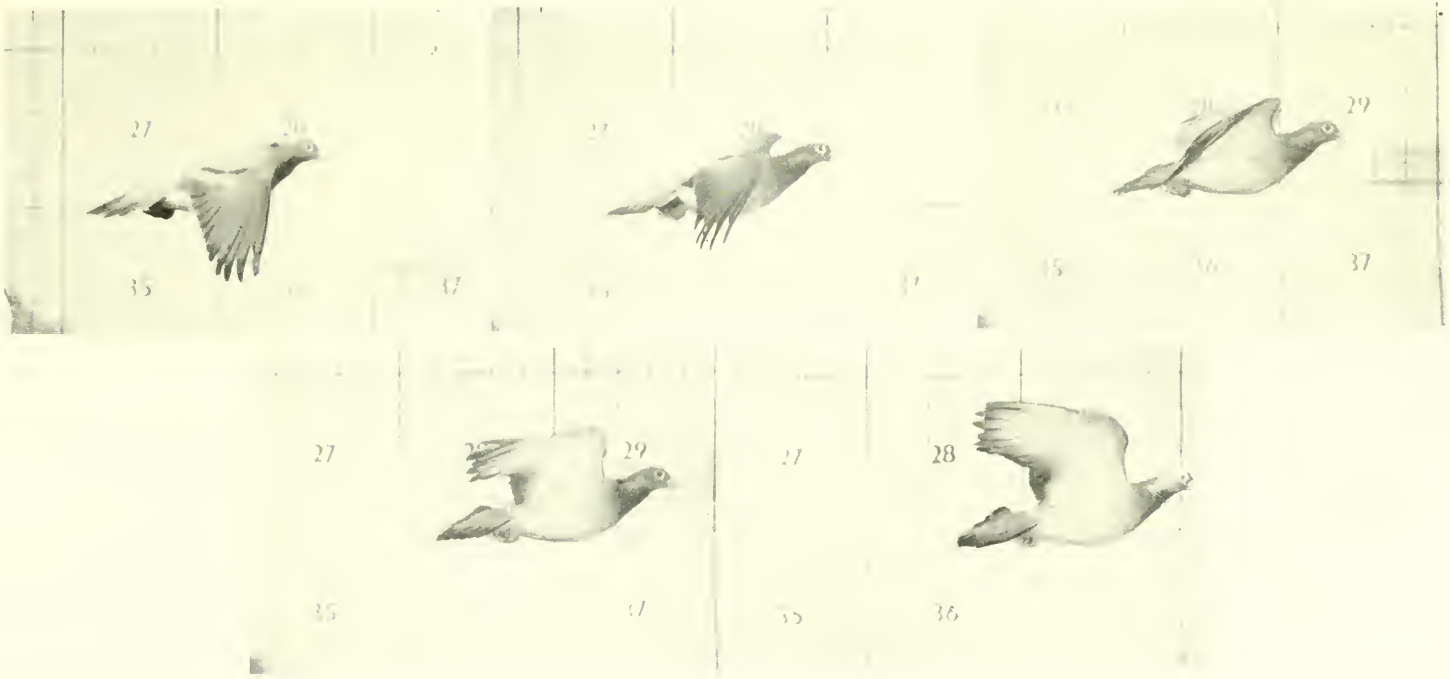


Plate 9 and 10, photographs of a pigeon flying at normal speed. Note how the wings no longer swing forward in front of the bird's head and how the backward flick at the end of the upstroke is greatly reduced.

Botanical Studies in Fiji

By Albert C. Smith

Department of Botany, U. S. National Museum, Smithsonian Institution

[With 12 plates]

One of the functions of the botanical department of a large museum, such as the U. S. National Museum, is to assemble from all parts of the world a representative collection of herbarium specimens. The value of such collections is often not appreciated by nonscientists, who may question the expenditure of public or private funds for the building of ever larger assemblages of dried botanical specimens, which in turn demand additional storage space and increased time of the staff for their maintenance.

The herbarium specimen is the fundamental tool of the plant taxonomist. Without reference to such specimens, his floristic and monographic work loses much of its value, because his conclusions cannot be checked by future workers. The importance of taxonomic work needs no justification for those who see biology as a whole. But in some circles, unfortunately, the museum and field work of taxonomists is looked upon with either impatience or good-natured tolerance, sometimes with an implication that such work belongs on the fringes of scientific endeavor, if indeed it should be dignified as anything more than an amiable hobby. That taxonomy is relevant to the progress of science, however, is apparent to anyone conversant with its objectives and its basic techniques. In fact, taxonomy is in large part a synthesizing branch of biology, and its practitioners derive their data from the fields of morphology, genetics, ecology, physiology, and cytology, not to mention the allied earth sciences of geology and geography. With the background of specialized techniques provided by these branches of science, the taxonomist, studying and analyzing great numbers of herbarium specimens, supplies the data and statistics that the phytogeographer and the student of phylogeny interpret. All branches of biology have become increasingly interdependent; by the integration of knowledge derived from many disciplines, we are gradually forging a real understanding of the world of living things.

The place of the large herbarium in this cooperative undertaking, as a basic source of documentation, is evident, and the contribution of the individual taxonomist, although often minute and sometimes seemingly remote, is fundamental.

It is hardly necessary for one to point to the contributions made by plant taxonomists toward the understanding and development of agriculture, toward a sound basis for ethnological and anthropological studies, or toward research in medicine. In World War II the part played by taxonomists in preparing a series of handbooks upon which the survival of military personnel in remote areas often depended is an irrefutable demonstration of a useful application of plant taxonomy. When the individual taxonomist makes collections of herbarium material, when he studies and analyzes such material, and when he publishes his floristic or monographic conclusions, he cannot anticipate for what practical end his data may eventually be utilized. But, in many instances, sudden and dramatic developments in applied science have been incalculably facilitated by knowledge already existing in orderly herbaria and in the published researches of taxonomists.

Quite apart from such practical considerations, however, I wish here to discuss only one of many theoretical aspects of plant taxonomy as it is related to the area of my special geographical interest, the southwestern Pacific. In this region much remains to be done on a preliminary level of taxonomic study involving the collection and identification of specimens. No taxonomist considers this type of work as more than the first step toward a larger project. In some little-known Pacific regions this first step has still not been firmly taken, and while we are taking it we try to look ahead and see how we may contribute, as taxonomists, toward an understanding of geological history. Phytogeography, or plant geography, is the study and interpretation of the distribution of plants over the earth's surface, and it is a field of research close to the interests of every plant taxonomist. It is not too much to say, perhaps, that every floristic study is a contribution toward one ultimate goal, a comprehension of the biogeographical history of the world.

Until we know with considerable accuracy what species of plants occur naturally in the region under consideration, we cannot intelligently discuss either their phylogenetic or migrational history. Therefore, to prepare a regional Flora or at least a well-documented list is the taxonomist's first concern, when he is satisfied that adequate, even though incomplete, field studies have been made. Without such basic knowledge the phytogeographer can go far astray in his conclusions.

In the Pacific, for instance, it is recognized that Fiji occupies a key position, the archipelago being situated on the eastern rim of an old Melanesian land mass that presumably broke up into its present iso-

lated remnants in Tertiary time. A knowledge of what plants are indigenous in Fiji today will help materially in an understanding of past earth movements in the region, especially if such knowledge can be correlated with similar data from the New Hebrides, the Solomon Islands, and New Caledonia to the west, and from Samoa and Tonga to the east. It is unlikely that the fossil record in this part of the world will ever be complete enough to give a true picture of Tertiary vegetation, and so we may have to depend upon an interpretation of modern vegetation for our eventual reconstruction of plant migrations. And yet, the only floristic study of Fiji of any completeness, an excellent study for its period, is the nearly century-old "Flora Vitiensis."[1] Obviously the phytogeographer who depends upon so outmoded a work for his basic information will reach unsound conclusions. For neighboring archipelagoes the picture is no more encouraging; in fact, for the New Hebrides and the Solomon Islands our floristic knowledge is much more fragmentary than it is for Fiji.

One of my preoccupations for more than 20 years has been a study of the plants of Fiji, my intention being to supplement Seemann's fine work with a Flora which, presumably, will give a more realistic picture of the modern vegetation of the archipelago. This intention has had its vicissitudes, but after three extended field trips,[2] during which approximately 65,000 herbarium specimens were prepared, I feel that a reasonably well-documented Flora can finally be visualized.

Perhaps I can best suggest to the reader the methods of a tropical-plant collector by briefly recounting in chronological order the events of my most recent trip. On earlier trips I had visited some of the outlying islands of the group and also representative portions of the two largest islands, Viti Levu and Vanua Levu.[3] Consequently I had in mind a few remaining "blind spots," which earlier collectors had either not reached or had visited only cursorily. These areas included a region of precipitous mountains, the Korombasambasanga Range, in south-central Viti Levu, the hills of Tailevu and Serua Provinces, in the east and south of the same island, and portions of the volcanic islands of Ovalau, Ngau, and Taveuni.

[1] Seemann, Berthold, Flora Vitiensis: A description of the plants of the Viti or Fiji Islands with an account of their history, uses, and properties, xxxiii+453 pp., 100 pls., 1865–73.

[2] The first of these trips, in 1933–34, was sponsored by the Bernice P. Bishop Museum, the New York Botanical Garden, and Yale University; the second, in 1947–48, by the John Simon Guggenheim Memorial Foundation and the Arnold Arboretum of Harvard University, with the aid of grants from the National Academy of Sciences and the American Philosophical Society; and the third, in 1953–54, by the Smithsonian Institution and the National Science Foundation. To the sponsors who have thus demonstrated an interest in the project I am deeply grateful.

[3] For itineraries of these trips, see Journ. New York Bot. Gard., vol. 35, pp. 261–280, 1934, and Journ. Arnold Arb., vol. 31, pp. 138–141, 1950.

The tropical-plant collector does not travel lightly. Because in most tropical countries one cannot hope for a local source of supply, it is necessary to take most of the collecting equipment needed, including considerable quantities of paper, driers, corrugated boards, small kerosene stoves, straps, envelopes, and the many other special things that are essential. In a country like Fiji, however, one can obtain kerosene for drying plants, axes, machetes, and similar standard items. Therefore, upon arriving in Suva in March 1953, with my wife and our two children, I disclosed to a somewhat baffled but very helpful customs officer more than a ton of baggage. At this point I might interpolate a word of thanks to all the government officials in Fiji; their courtesy and friendly cooperation at every stage of my work there has been exemplary. For a few days we renewed our acquaintance with friends made in 1947–48 and established new contacts, while planning a provisional schedule of fieldwork. The local Department of Agriculture generously gave me working and storage space and furthermore seconded to me a young Fijian assistant, Bernardo Vunibobo, to act as interpreter and "head boy" for the ensuing 9 months.

For our first headquarters, Bernardo and I selected a small Fijian village, Ndakuivuna, in Tailevu Province, eastern Viti Levu. This village is situated in a region of low hills between the sea and the Wainimbuka River, and from it we could collect in the thick rain forest that covers most of the southern and eastern parts of the island. As Viti Levu has an area of about 4,000 square miles and contains many peaks exceeding 3,000 feet, to make a complete botanical survey of this one island would take many years; consequently collectors can hope only to sample a number of representative habitats and elevations. Many of the high points of Viti Levu having been botanically explored with reasonable thoroughness, I hoped in 1953 to sample the middle-elevation forest of a few selected regions. The Tailevu forest, where it has not been invaded by European and Indian settlers and by the route of the highway around Viti Levu, remains largely undisturbed, as Fijian cultivation merely scratches the surface here and there.

In April the rainy season in Fiji is slowly approaching its unwilling end, and one becomes accustomed to ignoring the weather. Very soon I found myself in a familiar daily pattern bounded by the steep hillside gardens that ring the village, the little hunting trails, obscure and deep in mud, the wet undergrowth, the sudden drenching showers, and the noonday halt, with lunch of *ndalo* (*Colocasia*), yams (*Dioscorea*), and a tin of meat or fish. The collector's reward for spending a day in this manner is, to him at any rate, very tangible, if he obtains a few specimens of rare plants, perhaps new to the district or even to the island, perhaps known otherwise from one or two collections, or

perhaps not even recognized and potentially "new species." Of course the final identifications await herbarium study in future years, but the pleasure and excitement of plant hunting are adequate recompense for the discomforts involved. Return to the village in late afternoon, a dip in the stream, dry clothes, a hot and often excellent meal of varied native food, and a congenial evening of conversation around a bowl of *yanggona* (the drink prepared from *Piper methysticum*) round out the collector's day in very satisfactory fashion.

By the beginning of May I was back in Suva and ready to leave, with my family this time, for Ovalau, the principal island of Lomaiviti (Central Fiji). Levuka, on the east coast of Ovalau, was for long the principal Fijian center of European settlement, but since the capital was moved to Suva in 1882 it has lost much of its importance as an administrative center and a port. Ovalau, with an area of about 40 square miles, is the ruin of a large and complex volcano, comprising a central basin surrounded by peaks and steep ridges, the highest elevation being 2,053 feet. Aside from a road along the east coast, only trails connect the villages. The whole island, except for the north coast and many rocky pinnacles and cliffs, is covered with a luxuriant rain forest. Furthermore, although it is the type locality of a few species obtained by early collectors, it has not been intensively botanized.

On Ovalau our headquarters for 5 weeks was the village of Lovoni, lying in the beautiful valley in the center of the island. This superbly situated town is approached by a rough trail of about 4 miles, but the Roko (Fijian administrative official) arranged to have our considerable baggage carried in by men from Lovoni, each man taking a load of about 30 pounds. While most Fijian villagers are good woodsmen and are at home in their natural environment, I must particularly commend the people of Lovoni for their knowledge of plants, their forest skills, and their generous hospitality. The Lovoni, once considered a wild and predatory tribe who made life for the early residents of Levuka very uncomfortable indeed, are now outstanding among Fijians for their vigor, independence, and their satisfactory communal village life.

From the village of Lovoni we were able quite thoroughly to collect on the slopes and spectacular summits that ring the valley. The prolonged rainy season did not seriously dampen my enthusiasm for this beautiful Ovalau forest, its varied trees forming a dense canopy averaging a hundred feet in height, its undergrowth rich in shrubs of such plant families as Rubiaceae, Euphorbiaceae, and Gesneriaceae, its steep rocky slopes supporting masses of terrestrial orchids and ferns, and its exposed summits smothered in a diversity of moss-covered shrubbery. Usually I would spend about 3 days a week in

the forest, with 4 or 5 men to make trails and cut trees; the Lovoni men were pleased to give us their names for plants and to range far from the trail to bring specimens that would otherwise have escaped Bernardo and me. Without willing cooperation of this sort a forest botanist's work is limited, for the bulk of the material obtained and the labor of felling trees prohibit solitary collecting. On the remaining days of the week I would work in the village, making notes and drying specimens, and periodically my assistants would carry dried plants to Levuka and return with needed supplies. The little Lovoni River, flowing through the village, lends charm to the surroundings, where my family had their first prolonged experience of Fijian life. It is perhaps an unfortunate fact that Fijian villages are delightful in inverse ratio to the European and Indian contacts of their people.

After another brief stay in Levuka, we left on June 12 for Ngau, the southernmost and largest island of Lomaiviti, with an area of 54 square miles and elevations up to 2,345 feet. The 40 miles from Levuka were covered in a small copra-collecting cutter, which travels between Levuka and the Ngau villages two or three times a month. On Ngau we had a fine headquarters in Sawaieke, the village of the Mbuli (ranking chief) of the island, and this village served as a base until we returned to Levuka on July 7. I was particularly anxious to work on the heavily forested hills of Ngau, because botanically it is the most neglected of the larger Fijian islands; except for specimens obtained in 1854 by the botanists of the surveying ship *Herald*, there appears to exist no herbarium material of consequence from Ngau.

Although higher than Ovalau, Ngau is entirely different in topography, its sharp ridges leading to a central mass dominated by the twin peaks of Ndelaitho and Ndelaithomboni. While I was able to work on some fine forested slopes and spurs, I failed to reach the actual high points. In Ngau we had a sample of a sustained type of storm that the Fijians call *mbongiwalu* ("eight nights"), during which for a period of more than a week there is literally no break in the rain and the cold wind-driven mist. This is a "dry season" type of storm that must simply be endured; during it brief collecting trips are possible, but the high ridges are temporarily out of bounds.

Our final visit to Ovalau was spent for the most part at Thawathi, a Catholic Mission school on the northeastern coast. With the excellent headquarters provided by a dormitory during a vacation period, I was able to work on some of the northern peaks of Ovalau that were less accessible from Lovoni. It may now be felt that Ovalau, at any rate, has been adequately collected, but even here the occurrence of undescribed species is a probability.

The third largest of the Fijian islands, although it is only a fraction of the size of Viti Levu and Vanua Levu, is Taveuni, which has an area



1. View across the Rewa River Valley in Viti Levu from the hills of Tailevu Province, showing in the distance the mountains of Namosi Province, nearly 4,000 feet high, and the Namosi Gap, where the picturesque Waindina River breaks through the range.



2. Willing Fijian helpers carry the results of a day's fieldwork back to the village. The material, roughly pressed between sheets of paper, is carried in copra sacks, and the empty shoulder portfolio indicates a successful day.



1. Waikama Bay, on the island of Ngau, where the exploring ship *Herald* anchored in 1854 is of scenic as well as botanical interest.



2. Mount Ndelaitho, the high point of Ngau, is cloaked to its summit by a dense rain forest.



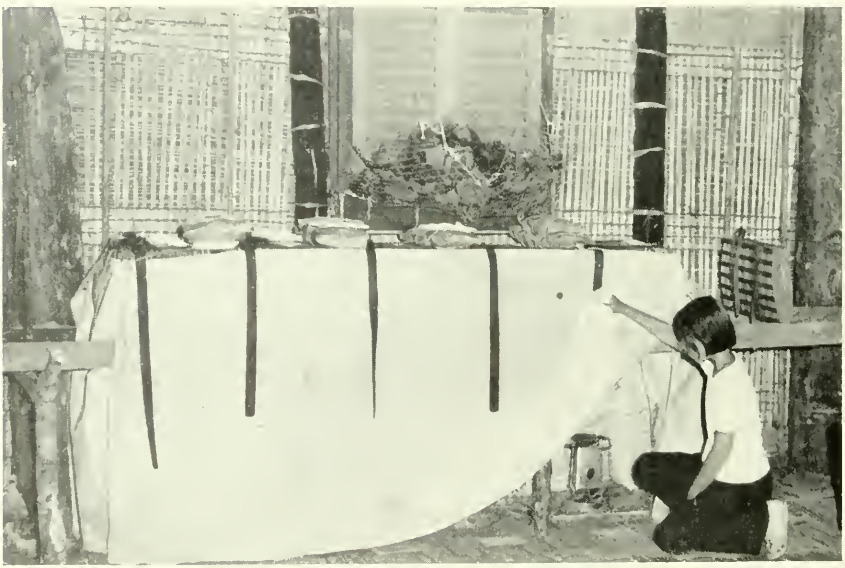
1. A flowering branch of *Hernandia ovigera*, one of the large spreading trees of the coastal forest.



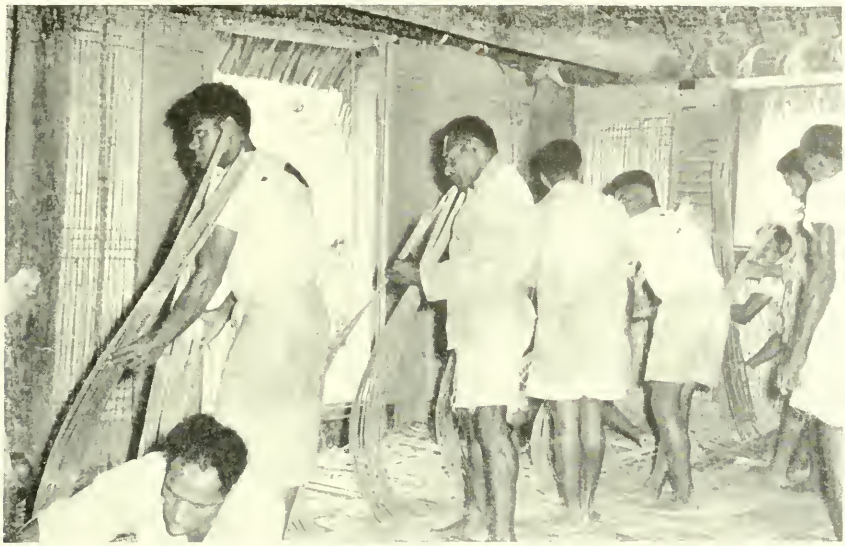
2. A common tree of the beaches is *Thespesia populnea*, of the mallow family, here shown in fruit.



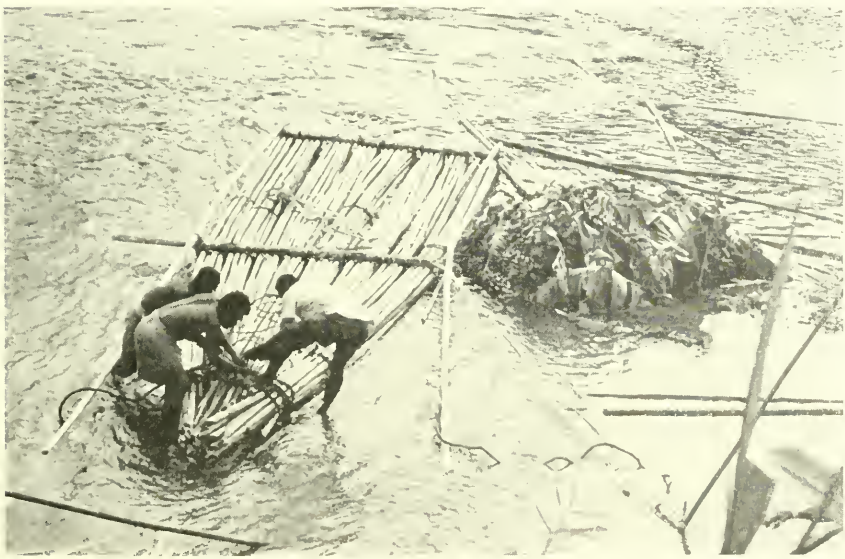
1. A footbridge of palm trunks and bamboo stems crosses a tidal creek on Ngau. The Fijians are adept builders with local materials, and such a temporary fiber-lashed structure is made in a matter of minutes.



2. A method of drying herbarium specimens. The plants, under pressure between blotters and corrugated boards, are supported above a source of slow and constant heat which drives out the moisture through the corrugations. Specimens thus thoroughly dried under pressure remain flat and durable for future study. Large fruits and leaves for chemical analysis are dried by the escaping current of hot air.



1. An introduced bamboo, *Bambusa vulgaris*, is widely utilized. Here a floor of woven split bamboo is being laid in a new house. The reeds lining the walls, of the large grass *Miscanthus japonicus*, are woven together with coconut or hibiscus fibers. Many species of forest trees produce the huge timbers that Fijians use in their houses, which are built entirely without the use of metal fastenings.



2. Bamboo makes strong rafts to carry loads of bananas down the rapids of the Navua River. These are "one-way" crafts and terminate their career at the river's mouth, the rapids prohibiting their return.



1. *Metroxylon vitiense*, the endemic Fijian sago palm, grows very locally in swamps. It lives about 25 years, produces a large terminal inflorescence, and then dies. Fijians esteem its fronds as the best thatching material in the archipelago.



2. The leaf segments of *Metroxylon vitiense* are taken from the leaves, bent around a reed, and sewed together with hibiscus fiber. "Shingles" about six feet long are dried in the sun and then tied to the rafters of the roof. Such thatching is said to be durable for 20 years or more.



1. The frame of the roof of a new house is made of saplings lashed together, and on this the *Metroxylon* "shingles" are tied with fibers.



2. An upright for a house is shaped from a tree trunk with an adz. The usual tools for house building in Fiji are the machete, ax, and adz.



1. The grass *Erianthus maximus* provides a delicacy; the undeveloped inflorescences, enclosed in leaf sheaths, are roasted over the coals. The cooked inflorescences look like large asparagus stalks and have a delicious maizelike taste.



2. A Fijian woman weaves a carrying basket from the fiber of *Freycinetia*, a relative of the screwpine, *Pandanus*.



1. A view of the Korombasambasanga Range from the village of Wainimakutu, in Namosi Province, Viti Levu. Vuimasia, the peak farthest to the right in this picture, has an altitude of 3,948 feet.



2. Another view of Korombasambasanga, showing the whole northern face of the range from the valley of Wainimbua Creek.



1. A large epiphytic fern, *Asplenium amboinense*, is a frequent component of the Fijian rain forest.



2. A much rarer plant is the little root saprophyte, *Balanophora fungosa*, which sends its inflorescences three or four inches up through the leaf mold. The whole plant is yellowish pink in color and lacks chlorophyll.



1. The writer's children, with an eager local assistant, collect insects for the National Museum's department of zoology.



2. An attractive seaside tree is *Guettarda speciosa*, with fragrant white flowers up to three inches in length.



1. A view from the island of Taveuni across Somosomo Straits to Vanua Levu. The reed-covered forehills of this eastern coast of Vanua Levu are due to burning, as normally the windward (southeastern) exposures of the Fijian islands are densely forested.



2. Children of Ngaloa practice a traditional spear dance, which they intend to present to their elders on a special occasion. Music is provided by the chanting and clapping of the seated group.

of 168 square miles and in elevation attains 4,040 feet, second in the archipelago only to Mount Tomanivi on Viti Levu. Taveuni has been visited by several botanists, and I spent some weeks there 20 years ago, but there still remain large upland areas in need of collecting. At a plantation on the east coast of Taveuni the highest normal annual rainfall for the archipelago has been recorded, averaging 213 inches. This eastern slope receives the full force of the trade winds, and the summit ridge is seldom clear of clouds; the rainfall at high elevations is probably close to 400 inches a year. One of the thickest forests in Fiji cloaks this precipitous eastern slope from sea to summit without a break. Because the shore is rockbound and unprotected by a reef, the area has no settlements and is difficult to approach. But my intention of working on the eastern slope of Taveuni was thwarted by a combination of circumstances, and we made our headquarters on the populated western coast, where there are several European coconut plantations and a few Fijian villages. This coast, for the lower 1,000 feet, is a nearly continuous belt of coconuts, above which the forest extends upward to the summit ridge.

The northern and southern extremities of the central ridge of Taveuni have been previously visited by botanists, and I had already twice ascended Mount Uluingalau, the high point. Therefore, in August I worked as thoroughly as time permitted on the slopes in the center of the island. It was a pleasure again to collect in the Taveuni forest, which abounds in huge trees of such species as *ndamanu* (*Calophyllum*), *vulavula* (*Endospermum*), and representatives of the Sapotaceae, Moraceae, and Leguminosae. Among the rarest plants to be seen on Taveuni should be mentioned *Trimenia weinmanniifolia* (the type species of a curious small family, Trimeniaceae), *Sukunia pentagonioides*, a rubiaceous shrub with large white flowers that I named in 1936 to commemorate the distinguished Fijian administrator Ratu Sir Lala Sukuna, and the beautiful liana *Medinilla waterhousei*. This last, the exquisite *tangimauthia* of Fijian legend, is a melastome with large red bracts embracing waxy white flowers. To my surprise, we found growing near the *tangimauthia* another species of *Medinilla* which is presumably undescribed, if anything even more spectacular, with rich pink bracts and flowers aggregated into huge inflorescences along the slender, twining stems. But perhaps my most exciting moment on Taveuni came with the recognition of an old friend, *Degeneria vitiensis*, the basis of a recently described plant family which we had previously known only from the two large islands.[4]

[4] The Degeneriaceae, believed to be among the most primitive of extant angiosperms, has been discussed in Journ. Arnold Arb., vol. 23, pp. 356–365, 1942, and vol. 30, pp. 1–38, 1949.

By the end of August we were again in Suva, planning for the final months of our visit, to be spent on Viti Levu. September and October are normally the driest months in Fiji, although on the windward (southeastern) slopes there is no real dry season. However, this was the best time to approach my main objective, the Korombasambasanga Range, and on September 7 we were on our way inland from Navua, at the mouth of the Navua River, near the middle of the south coast of Viti Levu. Collecting equipment and supplies for a projected stay of 2 or 3 months were taken inland. The first day of the journey was up the Navua River, utilizing three punts, pointed, flat-bottomed boats about 20 feet long which are well adapted for the rapids of the lower Navua. Six or seven strong and capable Fijian boatmen handle each punt, this specialized task being performed by men of certain upriver villages, who seem to have a monopoly on this form of river transportation. Ascending the rapids of the Navua gorges, one passes through some of the most scenic surroundings in Fiji, the river being flanked by steep forested banks and sharp cliffs, over which waterfalls plunge into the swift stream. For the most part there is no possible place where passengers can walk in order to lighten the punts, and the incredible boatmen, poling in unison, take their loads through the rapids a foot at a time, by sheer force.

Where the Navua River is joined by a smaller affluent, the Wainikoroiluva, is situated the village of Namuamua. This being the head of "navigation," the rest of our trip was made on foot, the baggage being carried by 13 horses, each with an attendant. The trail up the Wainikoroiluva valley is so rough that in places each horse has to be led or guided. For this part of the trip we took 2 days, reaching our destination, the little village of Wainimakutu, on September 9. The whole region is extremely beautiful, the river winding among sharp, steep hills and towering crags. The trail, if so it can be called, in general follows the stream bed and is passable only during the dry season. Between December and April, I was told, the people of the Wainokoroiluva valley are effectively isolated in the vicinity of their villages.

Wainimakutu is the "last" village in Namosi Province, situated in the valley of the little Wainavindrau Creek, which drains the western slopes of the Korombasambasanga Range. We could not have had a better headquarters for this phase of my work, as the spectacular group of cockscomb peaks rises near at hand above the village. The highest of them, Vuimasia, at 3,948 feet, is the second highest point of Viti Levu. The peaks of Korombasambasanga are massive columns of rock, ringed by precipices and divided by dark chasms. The steep and silent rain forest covers all but the sharpest slopes and cliffs. Such peaks are the denuded plugs of hard andesitic lava, remaining after the crater rims of the old volcanoes crumbled and eroded away.

My first two field trips in this region were made to a narrow ridge that connects Korombasambasanga with Mount Naitarandamu (3,781 feet), to the north. Collecting in this fine forest was excellent, the weather was clear, and the men of Wainimakutu were willing and competent assistants. It had aways seemed to me that the field men who have "adventures" create such situations by lack of foresight and planning, and I was feeling pleased, even smug, to have reached my goal with intact supplies, good health, and all the attributes essential to successful fieldwork. This was the situation about noon on September 14, as we had our lunch on the sharp little ridge called Ndevutu, studying the north face of Korombasambasanga and discussing possible routes up spurs to the jagged peaks. Two minutes later I had quite changed my mind about the causes of "adventures," for in the interval the most severe earthquake recorded in Fiji since white occupation had taken place. The men and I were lying flat on the exposed ridge, ludicrously holding on to the ground as if such contact would keep the shuddering ridge from sliding into the valley below. To the north, through dust-filled air, we saw a cliff on the summit of Naitarandamu slide down a newly scarred slope, and the terrifying rumble that issued from the earth on all sides made us too aware of a desire to be elsewhere. I suppose that one never feels more helpless than during an earthquake. Violent aftershocks spurred our scramble down the slopes to Wainimakutu, where we found the women and children sitting disconsolately on the village green.

It was some weeks before we learned of the considerable damage that had been done elsewhere in southeastern Viti Levu by the quake and tidal wave. During the ensuing months—at least into January—aftershocks were frequent and often sharp, and so I had to revise my plans to the extent of avoiding the peaks and cliffs that I had come so far to visit. The innumerable new landslides that now mark the region quite effectively discouraged me from high or very steep localities. But the following weeks were not lost, for collecting in the forest of gentler slopes proved highly profitable.

The forests of Korombasambasanga and its vicinity are too rich and diverse to make a listing of their principal elements meaningful, but it was always a pleasure to prepare ample material of species previously thought rare, in such genera as *Cyathocalyx*, *Aglaia*, *Elaeocarpus*, *Syzygium*, *Astronidium*, *Linociera*, *Couthovia*, *Cyrtandra*, and *Psychotria*. A special pleasure is derived by the collector who obtains the second or third collection of species described by himself, and in this region I met again my *Aristolochia vitiensis*, *Kermadecia ferruginea*, *Colubrina micropetala*, *Medinilla subviridis*, and *Plerandra insolita*.

On October 13, with farewell glances of regret upward to the now familiar outline of Korombasambasanga, we retraced our route to

Namuamua, which served as a base until November 5. Although generally similar to those farther inland, the forests of this "big bend" region of the Navua River disclosed some new elements, and the village itself, large and clean, was a pleasant headquarters. The earthquake had dislodged a cliff hanging over the mouth of the Wainikoroiluva River, which has now cut a new course through the rubble and is perilously close to the village itself.

After a brief respite in Suva, on November 12 we were settled in the large coastal village of Ngaloa, in Serua Province, southern Viti Levu. Here the hill forest reaches the coast in places, and only a short distance inland the ridges that gradually lead to the height of land between the sea and the upper Navua River are essentially undisturbed. A limited amount of timber cutting is done in this region, but fortunately the cutters do not go far from the road that follows the coast. The slope forest is dense and in general aspect resembles that of Namosi Province, but doubtless it contains a few different elements.

A final 2 weeks at the Catholic Mission of Lomeri, near Ngaloa, brought my work to a close. Here we enjoyed pleasant surroundings and European companionship during the Christmas period, returning to Suva on December 30. My collections in southern Viti Levu supplement the earlier ones of J. W. Gillespie (1927) and Otto Degener (1941), and I believe that this part of Viti Levu is now very well known botanically.

It was with considerable regret that I left Suva on January 7; not only is it beautifully situated and climatically delightful, but its people are hospitable in every way. In this brief summary I am unable to thank the many Europeans and Fijians who have so greatly facilitated my studies. Nor can I detail the valuable contributions that my botanical predecessors have made toward a new Flora of Fiji. My own visits have had the primary purpose of filling in some of the areas they did not reach, and our final knowledge of the Fijian flora will reflect the field and herbarium studies of many contributors.

Insofar as data on the flora of Fiji are now available, we know of 1,341 indigenous species of flowering plants, in addition to somewhat more than 500 species of adventive, or introduced, species. These latter, interesting as they may be as a record of man's settlement and visits to a region, cannot be taken as a basis for tracing the relationships of a flora. In such phytogeographic studies we must confine ourselves to the plants known to grow naturally, which were presumably established before the advent of man in the region. It is interesting to note that, of the 1,341 known species of indigenous Fijian phanerogams, 948, or 71 percent, are endemic, that is occurring in Fiji only. A high percentage of specific endemism is characteristic

of insular regions that have been isolated for a long period. It is probable that both the total number of species and the percentage of endemism will rise sharply with future exploration and study.

Any consideration of phytogeographical relationships is premature until the floras of the regions under study are thoroughly known, and in the Pacific such complete floristic knowledge is probably a century or two in the future. In the meanwhile, however, botanists can cast considerable light upon the problems of earth movement. A statistical analysis of the Fijian phanerogam flora,[5] however incomplete, shows that an overwhelming proportion of Fijian plants has its affinities with the plants of Malaysia, and especially those of New Guinea, the Solomon Islands, and the New Hebrides. Only about 5 percent of Fijian species appear to be closely related to groups that are typically New Caledonian or Australian, and only about 3 percent can be considered as belonging to strictly Pacific elements. A very few species have relationships toward New Zealand and what is thought of as an Antarctic element in the Pacific.

The result of this study, however incomplete and provisional it may be, is to support the hypothesis of land movement in the western Pacific most favored by geologists, namely that Fiji lies near the edge of a once-extended Melanesian continent that embraced New Guinea and Australia, and that its separation from other parts of the continent did not take place until the Tertiary Era. At this time, according to paleobotanical studies, the existing families and genera of flowering plants were already largely differentiated and often widely distributed. Our studies indicate that the last land connections to be sundered, as the old continent broke up into its present remnants, were those along the Fiji–New Hebrides–Solomon Islands chain. Land connections leading from Fiji toward New Caledonia and Australia must have been broken much earlier, if they ever were well established during the Tertiary.

In the southwestern Pacific we have, as it were, a laboratory for the study of plant speciation by isolation, and examination of the existing modern floras can be of great significance not only to phytogeographers but also to geneticists. Experimental biologists would do well to supplement the valuable findings of their laboratory research by turning to the far vaster laboratory of the earth's surface, where the evolutionary history of millions of years lies written, to be read in the light of cooperative research by students of all biological disciplines.

[5] Smith, A. C., The vegetation and flora of Fiji, Sci. Month., vol. 73, No. 1, pp. 3–15, 1951.

The Romance of Domesticated Plants[1]

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[With 11 plates]

Man's fate is closely correlated with events of the distant past—events which occurred even before he existed. One such incident, which was new among plants and eventually greatly changed the vegetative landscape, occurred about 225 million years ago. This accident resulted in the formation of a plant organ which we recognize as a seed. Heritable changes were not common in the more primitive seed plants, but finally, during the Cretaceous period (about 120 million years ago), the angiosperms made their appearance. All our common seed-bearing plants except the conifers belong to this group. This new kind of propagule was unique in that it contained an embryo plant which resulted from asexual union. Free water was not necessary in the fertilization process. Food, which could be used in further growth of the embryo and in germination, accumulated in the embryo and in surrounding tissues of the seed. This new plant organ could withstand desiccation yet remain viable for months to hundreds of years. In many instances, it could survive low temperatures which ordinarily would kill vegetative parts of the same plant. The nature of this organ was such that it could, at maturity, become widely disseminated within its habitat and to other habitats by several natural agencies.

[1] Presidential address delivered at the annual meeting of the Ohio Academy of Science at the Ohio State University, Columbus, April 24, 1953. (Publication No. 558, Department of Botany and Plant Pathology, Ohio State University.) Reprinted by permission from the Ohio Journal of Science, vol. 53, No. 4, July 1953.

[2] Credit is hereby given and appreciation expressed to the following for photographs for the illustrations: Tillman J. Johnson, figures 1–14, 16–20, and 25; Allan Heilman, figures 15, 26, and 27; Walter G. Wagner, O. S. U. Department of Photography, figures 21–23 and 28–39; and Dr. E. N. Transeau, figures 40 and 41.

By means of this new kind of propagule a very successful land flora became established, even over relatively arid regions, on all the continents except the Antarctic. All land habitats were more fully occupied by plants than before. The total vegetation mass was greatly increased, which in turn changed the characteristics of soils. The stream of heritable variations that occurred in seed plants is almost beyond comprehension. These occurred mainly before there were any humans in existence. The beginnings of some understanding of such matters is but a century old. Taxonomists now recognize about 10,000 genera and at least 300,000 species of seed plants. Many more will undoubtedly be discovered as time goes on.

SOME HERITABLE VARIATIONS IN SEEDS

Perhaps it is trite to point out that probably in every species of seed plant certain heritable potentialities may become expressed only in the seeds. Such were some of the characters in garden peas (*Pisum sativum* L.) which Mendel studied in his classical work of nearly a century ago—smooth and wrinkled seed coats, and yellow and green. From these seed characters (pl. 1, fig. 1) as well as variable characters from other parts of the pea plant, the fundamental principles of heredity applicable to both plants and animals were discovered. Though lost for nearly forty years, these principles, when rediscovered, sparked the new science of genetics at the beginning of the twentieth century. However, peas were not new to man in Mendel's time. They are among his oldest domesticated plants, the oldest recognizable remains dating 3000 B. C. from the Swiss lake dwellings of the Stone Age. The place of origin is in doubt, but may have been in the Mediterranean region or in western Asia. The pea as we know it is a cultigen, and botanists have been unable to locate it in the wild state.

The kidney bean (*Phaseolus vulgaris*) (pl. 1, figs. 3, 4) probably originated in Brazil. However, its greatest diversity was reached in Guatemala and Mexico. The Peruvians were cultivating it about 4,500 years ago. It was widespread among North American Indians. More than 500 varieties have been given names in recent times. Much the same story may be told for the lima bean (*Phaseolus lunatus*) (pl. 1, fig. 2). This illustration shows something of the remarkable diversity of lima beans as to size, shape, and color pattern. These are from a collection of present-day varieties found in Guatemala and Mexico. These two species of beans are sources of basic food materials used by millions of people.

The carob, locust bean, or St. John's bread (*Ceratonia siliqua*), a leguminous tree of the Mediterranean region (pl. 1, fig. 5), has pods that are used for human consumption as well as feed for swine and cattle. The pods have been identified by some with the locusts of John

the Baptist. The term "carat" has been applied to the carob bean or seed, and these seeds were used originally as a unit of weight, the carat. When mature, the seeds seem to be fairly uniform in size and very hard, and the seed coat is impervious to water until it is scarified. This imperviousness is a heritable characteristic and is found in the seed coats of many species. It is of concern to horticulturists, agronomists, foresters, and botanists. The waterproof coats of seeds and some fruits are obviously correlated with longevity of the embryo. The most prominent example is that of East Indian lotus (*Nelumbo nucifera* Gaertn.) (pl. 2, fig. 7). These are, botanically, fruits with a single seed inside. The fruit coat (pericarp) is the structure that is impermeable to water. When the fruit coat is notched germination may occur within 10 days. A quantity of these fruits was recently discovered in the depths of a peat bog in southern Manchuria. The seeds were viable and would germinate readily upon scarification of the pericarps. By the radiocarbon technique these seeds were shown by Libby in 1951 to be about 1,000 years old. The seeds and rhizomes have been used as food by peoples of Asia for many centuries. The North American species, the water chinquapin (*Nelumbo lutea* (Willd.) Pers.) was used as a source of food by the Indians.

In any seed collection one of the most conspicuous to be found is the castor bean (*Ricinus communis*) (pl. 2, fig. 6). This is not a legume but belongs to the spurge family. Though widely naturalized through the Tropics, it probably originated in Africa, with India as a second-best choice. In the seed coats we find remarkable variations in color and pattern, as well as in size and shape of the seeds. In addition, the endosperm synthesizes castor oil, which youngsters would readily proclaim as being a vile substance that should never have happened. In addition to its medicinal value, it is of importance industrially.

Another member of the spurge family is the Pará rubber tree (*Hevea brasiliensis*), with a few of its unusual seeds (pl. 2, fig. 8) exhibiting characteristic patterns. It is a native of the Amazon. Although found in negligible amounts in the seeds, a latex with high rubber content is synthesized in the vegetative parts of the plant. This tree is the chief source of natural commercial rubber. Although the natives are said to have learned to make rubber balls from the latex, and a crude syringe, and used it for waterproofing some clothing, nothing was done about domestication until recent decades. I need not dwell upon the importance of rubber in modern economy, but only to mention our experiences after the Pearl Harbor disaster.

Highly pigmented seeds are found distributed rather widely among plant families: The sword bean (*Canavalia gladiata*) (pl. 3, fig. 11) is from the Tropics of the Old World; the large seeds are edible and

they are used as ornaments. The rosary pea (*Abrus precatorius*) (pl. 3, fig. 10), another bean from the Tropics of Asia has a hard, scarlet coat with a black spot. These beans are used extensively in the Tropics for beads, rosaries, and other ornaments. The powdered seeds made into a paste and applied to arrows or darts make any wound fatal in about 24 hours. Seeds of the strychnine tree (*Strychnos nux-vomica* L.) (pl. 2, fig. 9), native of India and Indochina, are disk-shaped and about an inch in diameter. These seeds yield the very poisonous substance known as strychnine, which is of importance medicinally. Another species of *Strychnos*, native of South America, yields curare, a deadly poison used by natives for poisoning arrows, and now coming into importance in modern medicine.

The dye known as annatto, from the "lipstick plant" (*Bixa orellana*) (pl. 3, fig. 12), used in the coloring of oleomargarine, is a tropical American species. The dye is made in the outer soft, red layer seen in the illustration. This layer is an extra seed coat which is found in some species and is known as an aril. The spice known as mace is from the aril of the nutmeg seed. The edible part of the Chinese fruit called the litchi is the fleshy aril. Another seed with an aril (pl. 3, fig. 13) is from the bird-of-paradise-flower (*Strelitzia nicolai*) a mat of tangled orange-colored hairs which grow at one end of the seed; and another is the seed of the traveler's tree (*Ravenala madagascariensis*) (pl. 3, fig. 14), with the membranous, metallic-blue aril enfolding the seed. This metallic-blue pigment is unusual among plants. These last two species belong to the banana family. In neither case are the arils of any use to the plants, yet they continue to develop on each new crop of seeds and from generation to generation.

Seeds may vary through outgrowths from the seed coat, forming wings, spines, and hairs. The cotton seed (pl. 4, fig. 17) is an extreme example, with long hairs growing from the entire surface of the seed coat. These hairs certainly have no survival value to the cotton plant; in fact they are a disadvantage to distribution of the seeds in the wild state. There are many varieties of cotton (*Gossypium*) derived from indigenous species from both the Old and the New World. It is known that some Peruvians were cultivating cotton and were weaving textiles from it in 2500 B. C. Most of the cotton in cultivation in the United States is of American origin. These varieties have 52 chromosomes while the African and Asiatic varieties have 26 chromosomes and will not hybridize except on rare occasions. Because of this the Old and New World types have remained distinct even though they were brought together in our southern States in the earlier periods of cotton culture. Although the species of the two types will not readily cross, the hairs or fibers from the seed coats are very similar. It is remarkable that widely separated primitive peoples of the two

hemispheres independently learned to make textiles from the cotton fibers and domesticated the plants more or less simultaneously.

Variability in dimensions and weight of seeds may add to our appreciation of this plant organ. In various acid soil areas in Ohio, a native orchid, known as the rattlesnake plantain (*Goodyera pubescens* (Willd.) R. Br.), may be found. The seeds (pl. 4, fig. 16) of this plant are among the smallest known. The dimensions of this magnified specimen are approximately 0.02 inch long by 0.003 inch wide (641.4× 95.3 microns). The weight is about .000002 gram. Many other orchids have seeds with dimensions and weight in about this category. In addition, one of the tropical orchids is known to bear about a million seeds to a flower or fruit.

The natives of the Seychelles Islands in the Indian Ocean and Oriental lands bordering this body of water are accustomed to finding a somewhat monstrous object (pl. 4, fig. 15) washed up on the beaches. For centuries it was thought to be a product of the ocean and was called *coco de mer*, with many legends and superstitions developing about it. The hollowed-out shell was highly valued by potentates of the Orient as containers for drinking water. The shell was believed to contain an antidote to any poison that might have been added to the water. In the early part of the nineteenth century the fan palm (*Lodoicea sechellarum*) was discovered growing on Praslin Island. The nut, or stone, and seed are ordinarily two-lobed, appearing as though two large coconuts had partially joined, and are now commonly called the double coconut. Occasionally a three-lobed stone is found, which has led to the fallacy that a single fruit may bear from two to three seeds. There is but one seed to a fruit, which is usually two-lobed, about 13 inches wide and 12 inches long with a weight of about 40 pounds—the largest seed known.

If we were asked to pick out the plant family which is of greatest importance to man and other mammals, it undoubtedly would be the grasses (Graminaceae). There are over 10,000 species of grasses known, having a worldwide distribution, from aquatic to desert habitats and from the Tropics to the Arctic. The grains of grasses are, botanically, fruits—fruits with a single seed, which adheres to the membranous fruit coat or pericarp. The illustration on plate 4, figure 18, is a microscopic longitudinal section of a corn grain. The fruit coat is evident as a thin tissue surrounding the relatively large seed. The embryo is in the lower part of the grain, and the remaining large mass of tissue is the endosperm. This tissue is unique in that it develops ordinarily from the fusion of three nuclei, a male gamete and two nuclei of the embryo sac which are identical genetically to the egg or female gamete. Since these three nuclei are each haploid, the

endosperm nucleus, which results from the fusing of the three nuclei, is triploid, or has the $3n$ number of chromosomes or 30 ordinarily in corn. Since all the cells of the endosperm tissue are descendants of the triple-fusion nucleus, all the cells of the endosperm are triploid. While this is occurring, another male gamete fuses with the egg. The fertilized egg or zygote then is diploid or has the $2n$ number of chromosomes, which in corn ordinarily is 20. By cell division the zygote becomes an embryo, every cell of which is diploid, and as the growth, including cell division, continues, maturity of the plant is attained, with all the cells of the roots, stem, and leaves being descendants of the fertilized egg, each having the diploid number of chromosomes.

The corn endosperm (pl. 4, fig. 18, *E*) is noted for the great accumulation of foods, carbohydrates, and protein. It is a basic food source for many people, and has no equal as feed for farm animals. In 1952, 3,306,000,000 bushels grew on the farms of the United States. Numerous genetic variations (pl. 5, fig. 21) occur in the endosperm as to kind of carbohydrate, physical qualities, and pigmentation. In this illustration six fundamental endosperm types are shown on the ear—floury, dent starchy, flint, sweet, waxy, and pop. The floury type of endosperm has a high percentage of starch in relation to the protein content, is soft and readily ground by the primitive methods of the Indians, and was a common variety with them. Our common field corn varieties are of the dent starchy type. The flint type of endosperm is hard and hornlike, and was cultivated extensively by the Indians. Sweet corn, although known by the ancient Peruvians and by a few of the North American Indians in the latter part of the eighteenth century, never became important with them, and white man became interested in it about a century ago. Waxy corn is characterized by the presence of a waxy carbohydrate, erythrodextrin. Its culture history is uncertain. The Indians apparently made no use of it. Geneticists in this century found in it a useful tool in certain genetic studies and preserved stocks for that purpose. When World War II came along, cutting off the supply of cassava used in the manufacture of tapioca, a considerable acreage of hybrid waxy corn developed, the erythrodextrin being used in the making of tapioca and postage-stamp glue. Popcorn seeds have a hard, horny endosperm which explodes when heated, forming the white, soft, spongy mass of this popular confection. It was known and used by the ancients of Mexico and Central America.

Plate 5, figure 22, shows the results of crossing a pure-line red flint plant with a pure white flint corn plant. The ears borne on the white plant as a result of the cross pollination will be red-grained and the embryo in every grain will be hybrid. When these hybrid grains are planted and the mature hybrid plants are self-pollinated, the resulting ears will show a segregation of three red grains to one white, a typical

simple Mendelian ratio. If a pure white-grained plant is pollinated with pollen from a hybrid individual, the ear developing on the white plant will show a 1 : 1 ratio of red to white grains and demonstrate the "backcross" of the geneticists. Because of these heritable variations and many others, corn, or maize, has become one of the most important tools in the study of heredity.

Wheat (*Triticum aestivum*) (pl. 4, fig. 19) is another grain of the grass family, and has been in cultivation for at least 5,500 years. The earliest remains were found in Mesopotamia. The grain is not as large as the maize grain, but has a large endosperm with starch and protein accumulated in it. The wheat seed is a basic source of food, serving nearly half the human population of the world. In the United States the wheat yield was 1,291,000,000 bushels in 1952.

Some place in southeastern Asia, rice (*Oryza sativa*) (pl. 4, fig. 20) became domesticated earlier than 2800 B. C. Over 5,000 varieties have been recorded. The wild ancestor is unknown. The rice seed is a basic source of food for nearly a billion people.

MAN AND HIS DEPENDENCE UPON SEED PLANTS

By the beginning of the great Ice Age, the Pleistocene period, 1,500,000 years ago, the world stage of vegetation became set in such a way that our modern seed plants (angiosperms) were highly developed. A new actor began to make appearances on this stage—he was known as man. He was able to survive because he could obtain the right kind of food supply from the abundant flora, and materials were available from which he could make clothing and construct shelter, and which he could use as fuel for warmth and solace for his ailments. He was a wanderer, endowed with intelligence far superior to any other animal, and had inherited knowledge of how to survive from his primate ancestors. It was essential for him to have intimate knowledge of the plants which were useful to him as well as those which were harmful—developing the rudiments of plant taxonomy. He learned to make weapons in protecting himself from other animals, and eventually to use these animals for food and their skins for clothing. Some groups learned to live almost entirely by hunting, making it necessary to follow the herds. Some were gatherers of food, or perhaps combined the two methods of livelihood. They learned, perhaps, to care for particular trees that bore desirable fruit. In digging for edible roots, bulbs, tubers, and rhizomes, they became aware of vegetative propagation.

Some of the more botanically minded noticed that some of the seeds they ate had sprouts on them, and upon looking further saw various seedlings develop to mature plants bearing the same kind of seed. The discovery of these relatively simple processes and attendant re-

lationships was no doubt slow and torturous. Primitive man learned not only to collect and plant the seeds but to care for them in various ways. He learned how to store them in the interval between collecting and planting, and how and where the planting should be done. He observed that when planted in some organic waste, the plant grew better and bore more seeds and fruit. He became aware of differences in the various propagules and selected for planting those which appeared most desirable to him. These were the beginnings of horticulture and agriculture.

As the primitive hunters populated the continent of their origin, some groups migrated to other continents when opportunities arose. A land bridge once existed from Africa across Sicily to Italy, over which plants and animals, including early man, probably migrated. Owing to the vast accumulation of water in the form of glacial ice, sea levels were lowered to such an extent that land connections were possible between Siberia and North America in the area of Bering Strait. Bands of Asiatic hunters entered Alaska by this route, eventually populating both North and South America. The most direct route would cover more than 5,000 miles from the Arctic through tropical climates, establishing a great number of primitive cultures, eventually leading to the establishment of the classic civilizations of the Incas, Mayas, and Aztecs, within a period of about 15,000 years. Though fantastic, this is based on the best inferences of archeologists and geologists.

The movement of the Siberian primitives into North America must have been slow, perhaps taking many human generations. They came from a cold northern region which probably had no agricultural plants. There is no evidence of even a single species of domesticated seed plant having arrived from Europe, Africa, or Asia in pre-Columbian times. It is possible that man arrived in North America before there were any domesticated plants in Asia or elsewhere, and that domestication of plants in this hemisphere may have occurred more or less simultaneously with that of the Old World. As these people moved into the Americas they came in contact with a vast new seed-plant flora with geneplasms very different from those known to their ancestors. The Indians are known to have made use of over a thousand species of native plants in what is now the United States. Out of these only the sunflower and Jerusalem artichoke can be regarded as domesticated. However, many species were added to the list from Mexico, Central America, and South America.

DOMESTICATED PLANTS NATIVE TO THE AMERICAS

A partial list of the more important plants domesticated in pre-Columbian times may help us visualize and appreciate the efforts of

the first people of the New World. Maize or corn, with perhaps more than 8,000 varieties and the only important cereal which originated in the Americas, should head the list; the potato in its many varieties, now a staple food of many millions of people; the sweetpotato without which no vegetable counter is complete the year round, also a great source of commercial starch; cassava, a staple food in the Tropics, and a source of waxy carbohydrate used in the manufacture of tapioca; arrowroot and canna yielding starch for fine pastries; lima beans in considerable variety; kidney beans, from which snap beans, soup beans, and field beans developed; tomatoes, millions of tons being consumed annually in the United States today; hot and sweet peppers, widely used as condiments and to camouflage left-over ground meats; tobacco, introduced into Europe about 450 years ago, which has become the "sovereign master of practically all mankind"; coca, which yields cocaine, a narcotic used by millions of addicts; cocoa or chocolate; annatto, a vegetable dye, now used extensively for the coloring of oleomargarine, butter, and cheese; peanut, squash, pumpkin, and the chayote; and important fruits such as the pineapple, avocado, papaya, guava, custard apple, and the sapodilla.

It may be pertinent to point out here that all the basic food plants upon which we are dependent came into existence in pre-Columbian times. No new basic food plant has developed from the wild species in either hemisphere since that time. The Concord, Catawaba, and Delaware grapes derived from our native fox grape; the cranberry derived from the wild species, long used by the Indians; the modern strawberry has resulted from hybridization of the North American species and a Chilean species. The above grapes, cranberry, and strawberry developed during the nineteenth century, and in the present century the blueberry has been added. Important as they are, these can scarcely be regarded as basic food plants.

HOW DOMESTICATED PLANTS DIFFER FROM WILD SPECIES

Domesticated plants differ from wild species in that the domesticated species ordinarily cannot survive without human assistance, such as planting (sowing or propagating), protecting, selecting, and preserving. How these practices may best be accomplished is a major concern of horticulturists and agriculturists.

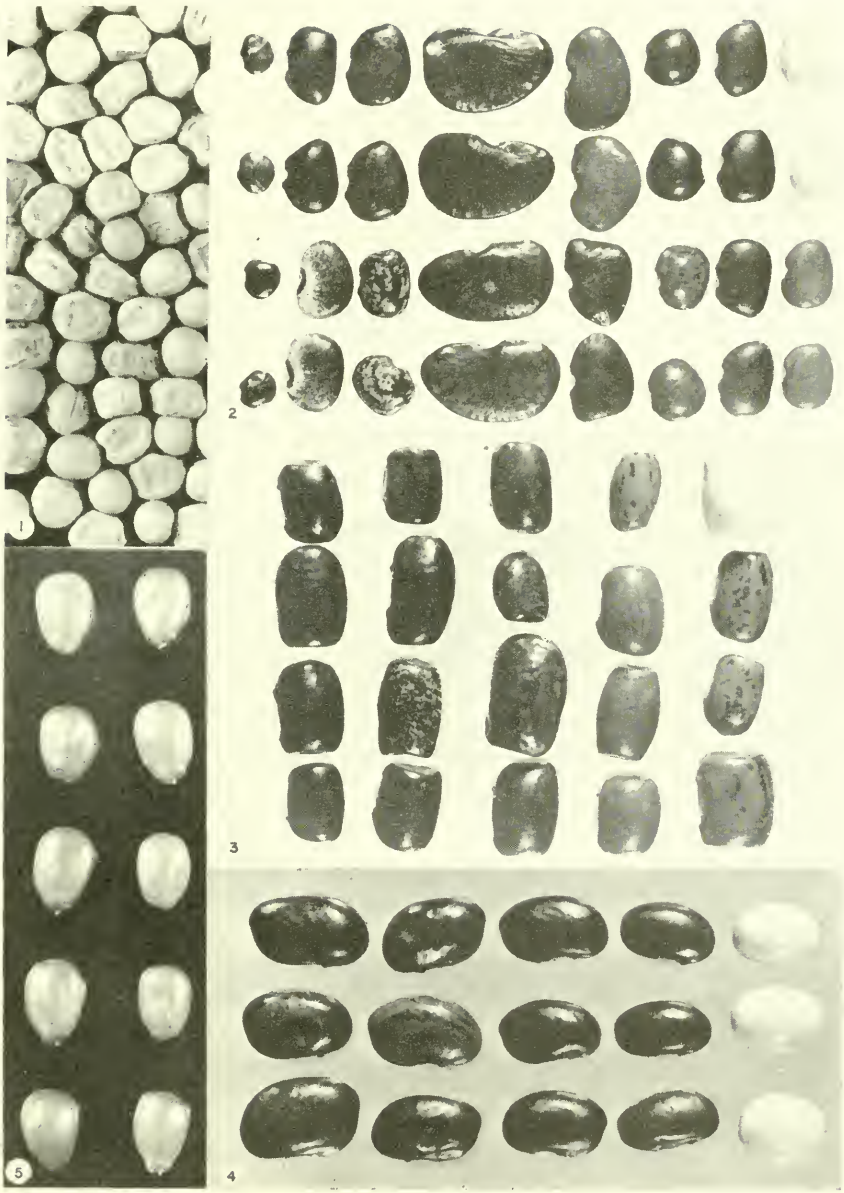
Heritable variation among seed plants is the rule rather than the exception. The frequency of this variation may be high for some species and low in others. The quality of the variation may range from something that is of great value in survival of the species growing in the wild, to characters which are neutral, through degrees of inhibiting influence to lethal variations. It should be kept in mind that such variations occur in an individual plant of a species, and

never simultaneously in all individuals in the population of a given species. If one wishes to observe such variations, he must study individuals. The early horticulturist had incentive to observe and tend individuals in his small garden, rather than large segments of a population, since he was dependent on the small patch for food. Any variant that met his needs better was selected, protected, preserved, and finally propagated. It was selected because it suited his purposes, and without regard to the survival value of the plant growing in the wild state. If good enough, from his standpoint, he would plant his whole plot to the variant and eliminate the less desirable ancestral type. Other members of his tribe planted it too, and eventually many groups in a large area were culturing the new and desirable variant. Additional variations occurred from time to time and were allowed to accumulate. Eventually the accumulated heritable differences were so great that the wild ancestor was no longer recognized. This is the case with a large number of domesticated plant species from both the Eastern and Western Hemispheres, such as the garden pea, rice, potato, and tobacco, with maize or corn as the crowning example.

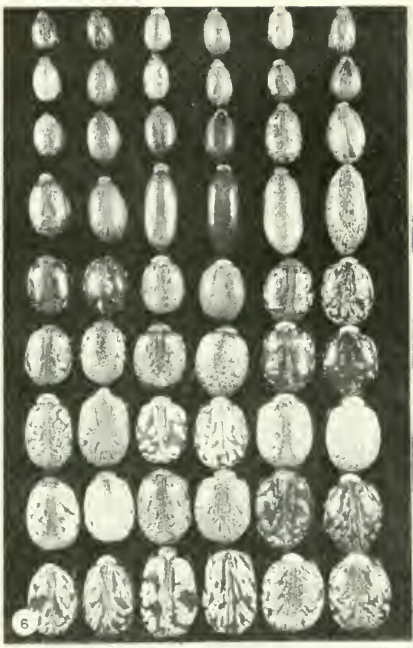
The wild ancestor of corn is unknown. It has either become extinct, or is so different in appearance that it has not yet been recognized. There is some evidence that pod corn was cultivated by the Cochise Indians of Arizona about 3,000 years ago (pl. 5, fig. 24). Pod corn differs from ordinary maize in that each grain on the ear is enclosed in a husk (bracts of the spikelet bearing the grain). The pod character is controlled by a single dominant gene. Some have regarded this as being the original wild corn. This notion has been questioned, since pod corn is no more able to survive in nature, without the aid of man, than is ordinary corn. The pod character is readily transmitted to any other variety of corn by cross pollination, resulting in a new combination or a recombination of characters. A similar case was mentioned earlier in which white flint corn was crossed with red flint. Any of the many varieties of corn will readily cross. This hybridization went on in gardens of primitive man, and undoubtedly occurred more rapidly than in the wild state because of the greater concentration of plants.

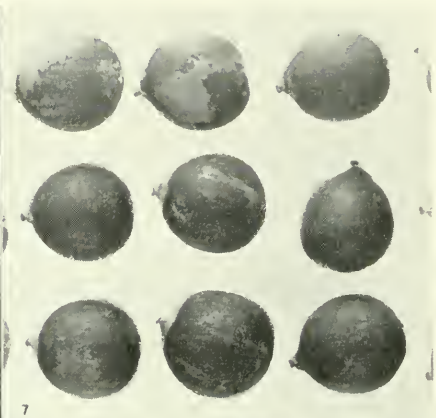
In some plants (maize being the outstanding example) the hybrid (heterozygous) individuals are more vigorous than either of the parents. Man was unaware of this hybrid vigor (heterosis) until Shull discovered it in 1908 and 1909. This discovery was not put to practical use for almost 25 years. Now, about 90 percent of corn acreage is hybrid. The use of hybrid seed for planting may result in an increase in yield of as much as 25 percent. This ranks as one of the greatest achievements in plant breeding.

Some place in the area from Mexico to Honduras, in the pre-Columbian period, there is evidence that maize crossed with the gamma grass



1, Garden pea (*Pisum sativum*) seeds. 2, A collection of lima bean (*Phaseolus lunatus*) seeds from Guatemala, varying in size, shape, color, and seed-coat patterns. Most of the dark-colored areas are shades of red. 3, 4, Common bean (*Phaseolus vulgaris*) seeds from Guatemala and Mexico. These and the lima beans of figure 2 are from a collection made by Webster McBride. 5, Seeds of St. John's bread (*Ceratonia siliqua*).

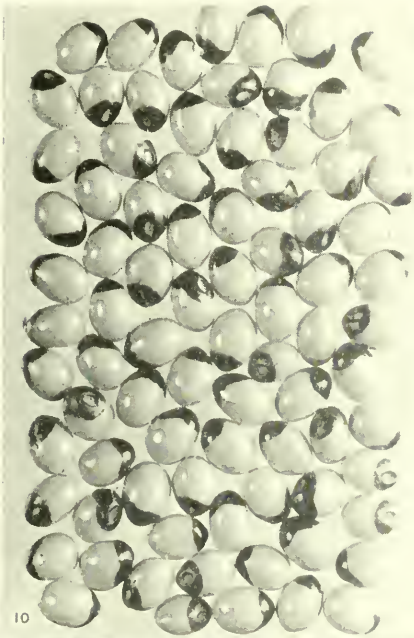


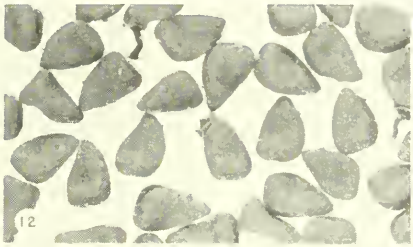


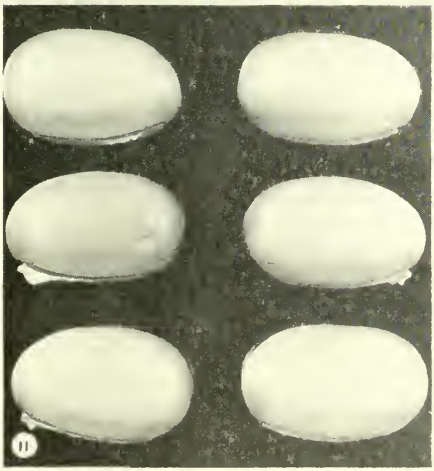


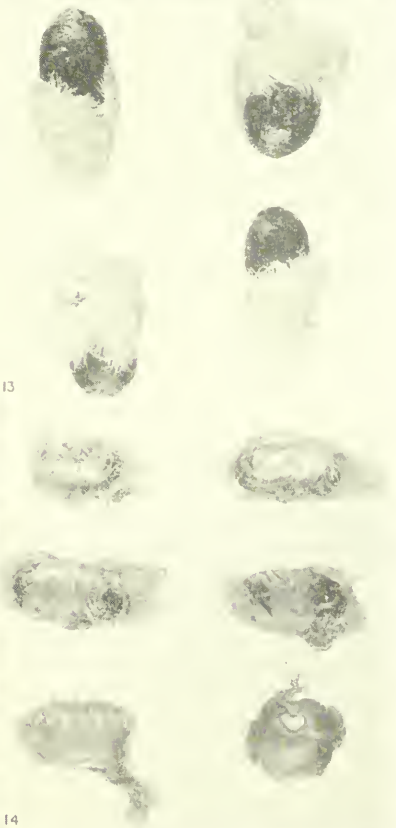


6, Castor bean seeds. 7, Fruits of lotus (*Nelumbo lutea*). 8, Seeds of Pará rubber tree (*Hevea brasiliensis*). 9, Seeds of strychnine tree (*Strychnos nux-vomica*).









10, Rosary pea (*Abrus precatorius*), scarlet with a black spot about the hilum. 11, Sword bean (*Canavalia gladiata*) seeds of a purplish-red color and an inch or more in length. 12, Seeds of annatto (*Bixa orellana*) with velvetlike coat of a maroon color. These, with the *Abrus* of figure 10, were supplied by Capt. Wm. A. Fuller, Cocoa, Fla. 13, Seeds of bird-of-paradise-flower (*Strelitzia nikolai*) with a brilliant orange-colored aril. 14, Seeds of the traveler's tree (*Ravenala madagascariensis*), with the membranous, fringed, metallic-blue aril enfolding them.



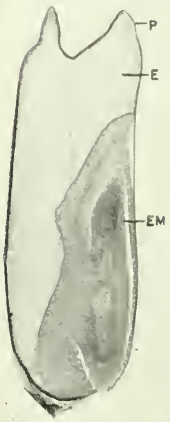
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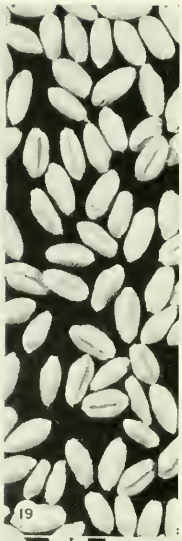
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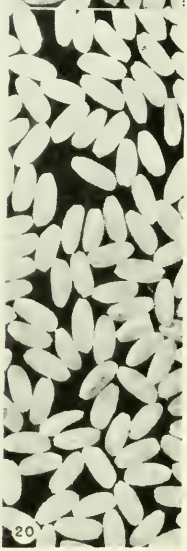
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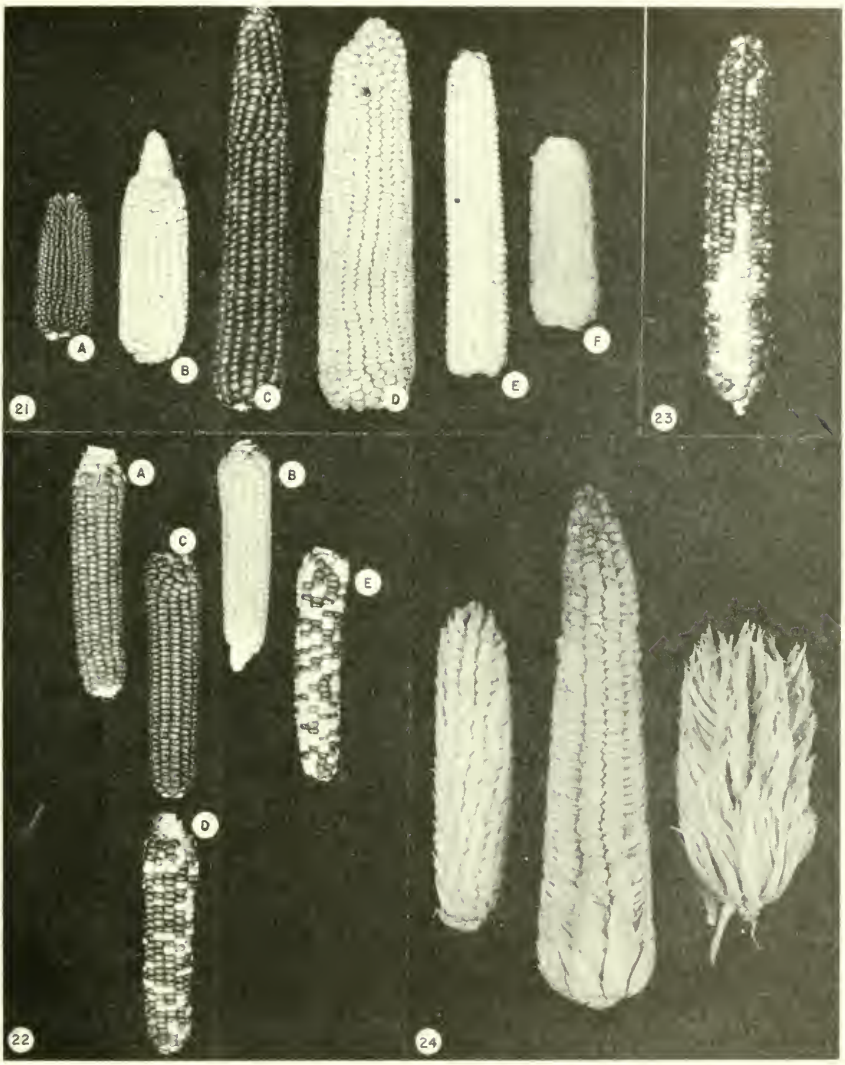


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15, Double coconut, the largest seed known. 16, A photomicrograph of rattlesnake plantain seed, among the smallest known. The oval body is an embryo within the seed coat. 17, Cotton seeds. 18, Longitudinal section of a corn grain with the membranous pericarp (*P*), large endosperm (*E*), and the embryo (*Em*). 19, Wheat grains. 20, Rice grains.



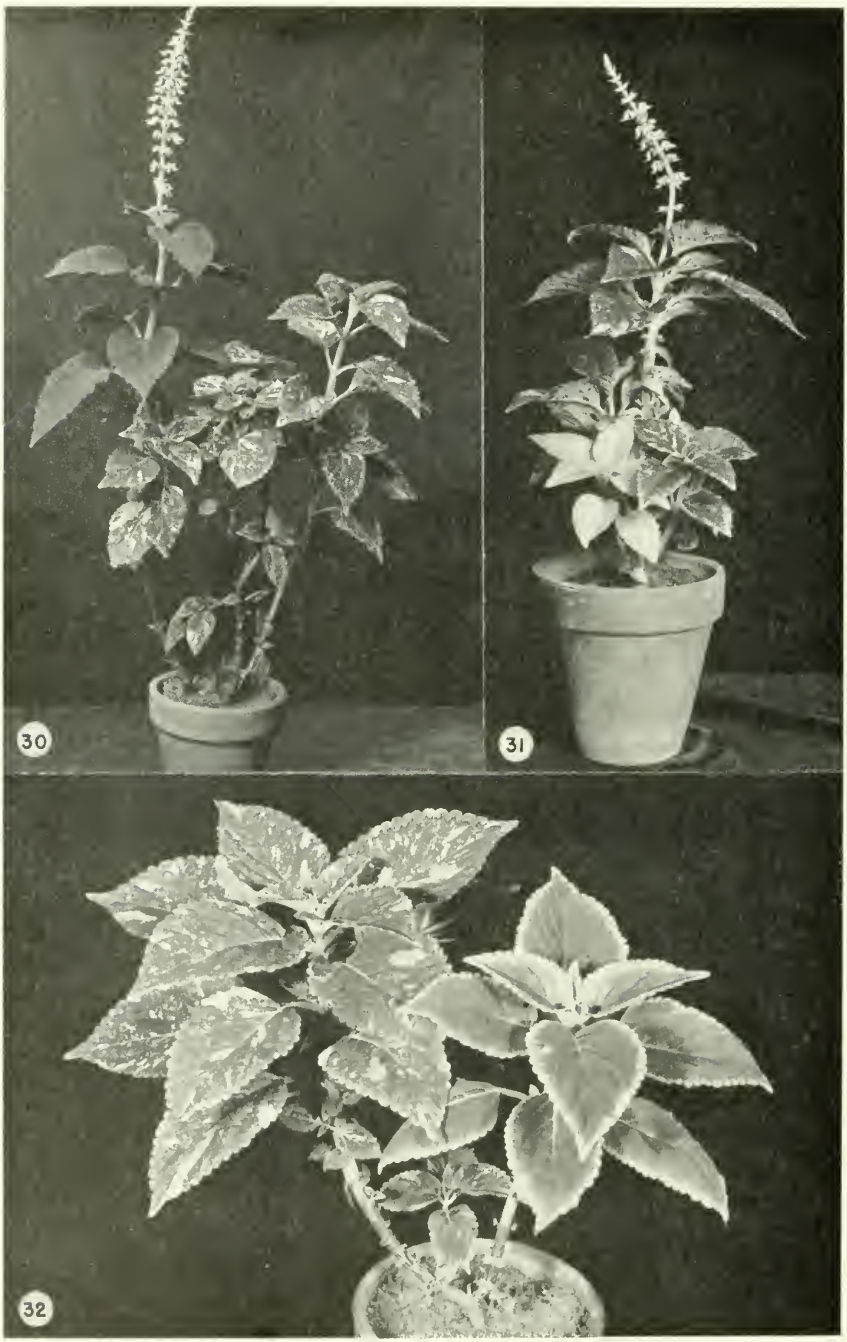
21, Six endosperm types of corn: *A*, Red Pop; *B*, Waxy; *C*, Red Flint; *D*, Yellow Dent Starchy; *E*, white flour; *F*, sweet corn. 22, *A*, Pure Red Flint; *B*, White Flint; *C*, hybrid; *D*, ear from selfed hybrid showing segregation; and *E*, with a 1:1 ratio of red to white grains, resulting from a back-cross of a hybrid (*C*) with the recessive white (*B*). 23, An ear of variegated maize with a block of white and yellow grains near the base, which are the result of a mutation having occurred. 24, Pod corn variation.



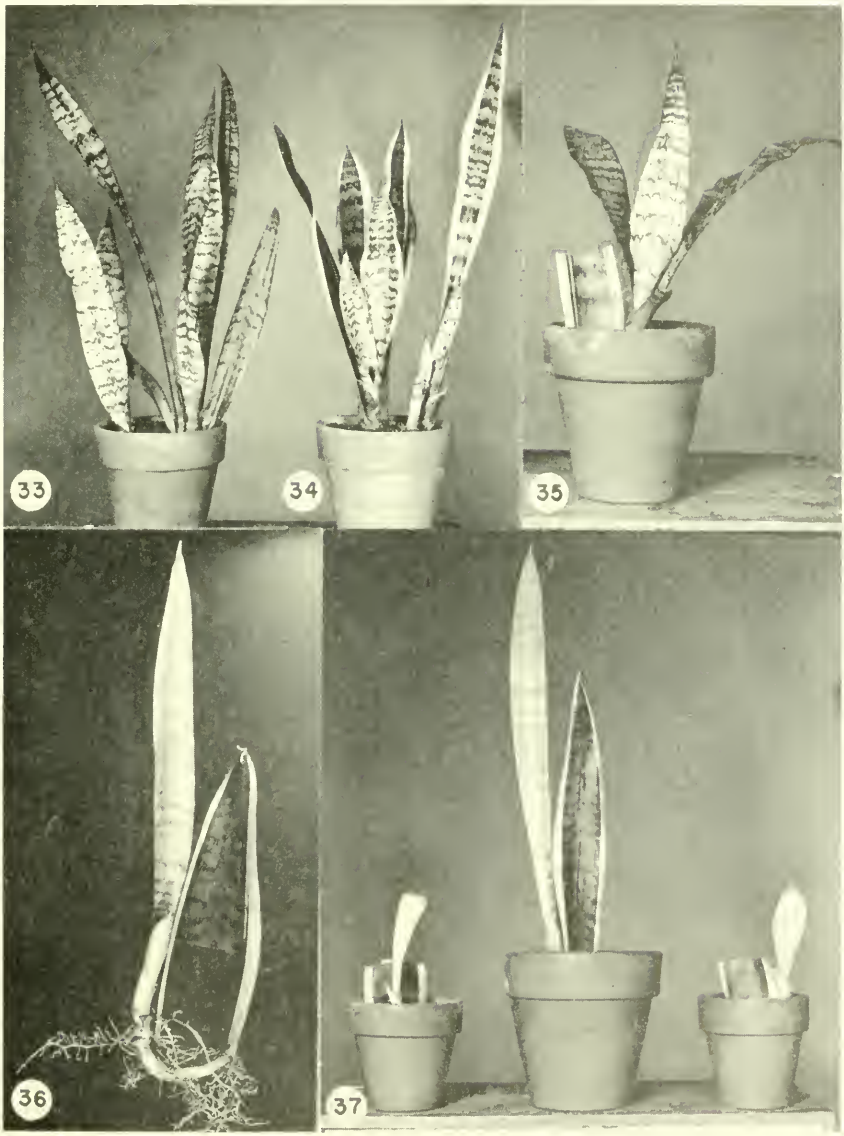
25, The common day lily (*Hemerocallis fulva*, clone *Europea*).



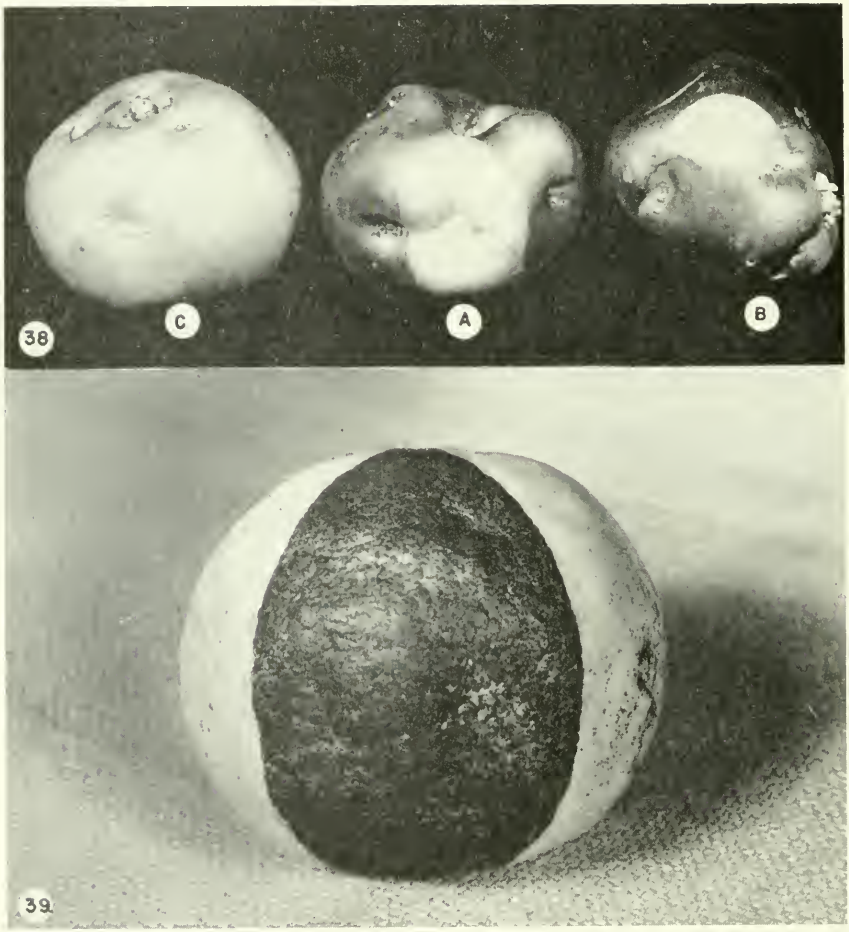
26, Ulrey's variegated African violet. 27, A variegated specimen of Orchid Wonder variety of African violet. 28, Mme. Solleroi geranium. 29, Silver Leaf S. A. Nutt geranium.



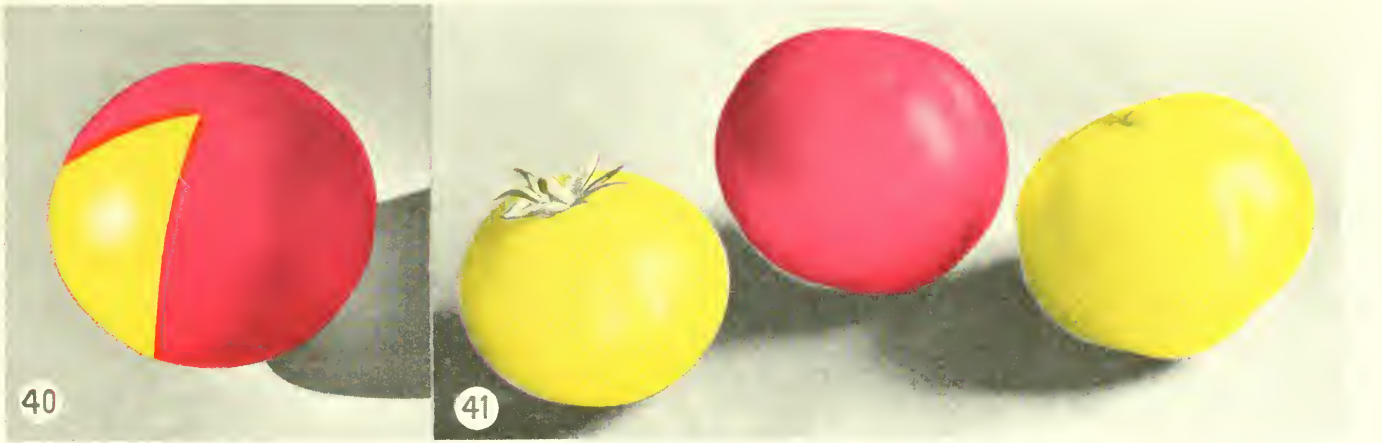
30–32, Mutations from a splotched-leaf type of variegated *Coleus*.



33, *Sansevieria trifasciata*. 34, *S. trifasciata* var. *laurentii*. 35, *S. trifasciata* shoot developing from a leaf cutting of var. *laurentii*. 36, 37, Yellow shoots originating from yellow tissue of a leaf cutting of var. *laurentii*.



38, *A* and *B*, Chimaeral tubers of the Red Triumph potato; *C*, white tuber which resulted from peeling a bud from red tuber as a propagule. 39, A sectorial chimaera of grapefruit.



40, A sectorial chimaera of a tomato fruit. 41, Plants from seed of the yellow sector (fig. 40) bore yellow tomato fruits, while those from the red portion of the chimaera continued to bear red fruits (second fruit from right).

(*Tripsacum*), and from the hybrid or its segregates teosinte (*Euchlaena*) resulted. The crossing of these two genera is difficult, but it has been accomplished in a few instances by Mangelsdorf and Reeves, by means of a special technique. The chances for it to occur in nature are remote. However, teosinte has a set of chromosomes which appear like those of corn and a set similar to *Tripsacum*. Taxonomists have given teosinte the rank of a new genus (*Euchlaena*) since it is so different from either *Tripsacum* or corn. If the above story is true, we have the unusual case of hybridization between two genera resulting in a third genus of grasses. The early Indians did not make much use of teosinte as a domesticated plant, but it is used now to some extent as a forage plant.

A CAUSE OF STERILITY IN SOME HYBRIDS

Hybridization between two rather distantly related individuals often results in the hybrid individual's being sterile. This sterility may be due to differences in the chromosomes from the male parent and the female. These differences may not prevent fertilization's taking place when the male gamete comes in contact with the egg cell. If this occurred in the day lily (*Hemerocallis fulva*) the sperm would have 11 chromosomes and the egg would have 11 chromosomes. The fertilized egg or zygote would have 22 chromosomes or the diploid number. There is no orderly arrangement of the 22 chromosomes within the zygote nucleus. The zygote divides mitotically, resulting in two new cells which are identical as far as the chromosomes are concerned, and each is identical to the zygote from which it came. In the same way, since the leaves, stems, and roots originate from the embryo by the same kind of cell divisions, it becomes evident that all cells of the vegetative plant are identical. This is also true for the flower parts up to and including the so-called mother cells of the anthers and ovules. The mother cells are the immediate forerunners of the gametes. However, it is common knowledge that gametes (sperms and eggs) have the monoploid number of chromosomes, or half the number found in any cell of a leaf stem, or root. The reduction from the diploid number to the monoploid occurs in the first two divisions of the mother cells in the anthers and ovules. The sperm of a day lily, as stated above, has 11 chromosomes which we might label a, b, c, d, e, f, g, h, i, j, and k. An egg cell of this same kind of plant has 11 chromosomes which are similar and could legitimately be labeled from a to k when the egg and sperm fused. There is a random assortment of these two sets of chromosomes in the zygote, and this is continued throughout all vegetative or somatic cells to and including the mother cells of the anthers and ovules. However, at this point, the chromosomes become assembled in pairs within the mother-cell nucleus, a pairing with a, b

with *b*, and so on through the *k*-pair. As division continues, the members of each pair of chromosomes separate, moving to opposite poles, with a wall eventually separating the two groups. The two new cells have half the number of chromosomes found in the mother cell. If this occurs in the anthers, the end result will be male gametes; if in the ovule, the egg cells will develop. The diploid phase starts again upon fusion of a sperm and egg.

However, if one of the sets of 11 chromosomes forming the egg were sufficiently different that we would have to label them *p*, *q*, *r*, *s*, *t*, *u*, *v*, *w*, *x*, *y*, *z*, pairing of the chromosomes previous to the reduction divisions usually would not take place, and the cells would abort. Ordinarily no fruit or seeds can develop. This is what apparently happens in the common day lily (*Hemerocallis fulva*, clone *Europea*) (pl. 6, fig. 25). This day lily was introduced from Europe perhaps over a century ago. Although no fruits or seeds ever develop, it propagates readily from the rhizomes. It is found thoroughly established along roadsides and railroads in many parts of the country—dumped there as waste from someone's garden.

The seedless fruit varieties of orange, grapefruit, pineapple, banana, grapes, and persimmons are further examples of sterility because of irregularities in gamete formation, but differ from the day lily in that the pistil of the flower, although sterile, does not abscise, but continues to grow, and matures as a seedless fruit. Such plants cannot survive in the wild without the aid of man.

As stated previously, all cells of the vegetative parts of a seed plant ordinarily are diploid, established by the fusion of the two monoploid gametes. The diploid number is maintained by the mitotic cell divisions. In this kind of division, the chromosomes set is duplicated in every division. Occasionally an accident happens which prevents the formation of a new cell plate and the duplicated chromosomes remain together in one cell. The diploid number is doubled by this method and the cell is a tetraploid. If this accident should occur as the zygote divides, every cell of the embryo, seedling, and mature vegetative individual will be tetraploid. If it occurs in one cell of a two-celled embryo, the shoot may be tetraploid and the root diploid, or vice versa. If it occurs in a somewhat older embryo, only that portion of the shoot derived from the original tetraploid cell will have the $4n$ number of chromosomes with other parts remaining diploid. This tetraploid state may occur spontaneously or it may be induced by treatment with colchicine and a few other reagents. Tetraploid plants, in general, may have thicker leaves, and larger stems, flowers, fruits, and seeds. Such plants are usually slower in growth, and consequently are later in flowering and fruiting.

Somewhere in western Mexico, the tetraploid condition developed in the annual teosinte mentioned previously. The tetraploid plant has

40 chromosomes and is a perennial. The annual teosinte has 20 chromosomes. The tetraploid form has been described as a new species.

Some nurseries list as available a hybrid horse chestnut (*Aesculus carnea*). It is a tetraploid having 80 chromosomes and will "come true" from seed. It is known to have resulted from a cross between the horse chestnut (*Aesculus hippocastanum*) with 40 chromosomes and the red buckeye (*Aesculus pavia*), also with 40 chromosomes. With the exception of one case, the hybrids were sterile. In the one instance, doubling of the chromosomes must have occurred, resulting in a complete set of horse chestnut chromosomes and a complete set from the red buckeye in the hybrid zygote. The chromosomes at meiosis could pair and separate in the usual way, and the usual segregation in a hybrid would be prevented. This illustrates how a new species may be synthesized through hybridization and the doubling of chromosomes.

The bread wheat, as mentioned earlier, is thought to have arisen in the region of ancient Babylonia. Bread wheat has 42 chromosomes. Emmer (*Triticum dicoccum*) with 28 chromosomes, another wheat somewhat useful as livestock feed, crossed with a noxious weed, goat grass (*Aegilops squarrosa*), with 14 chromosomes, and became the parents of the world's most valuable food plant! This must have occurred by the doubling of the chromosomes in the zygote (fertilized egg) or by the fusion of two unreduced gametes, giving the same result. This kind of heritable variation is by no means uncommon, as one might be led to believe from the above illustrations. It is probable that similar changes were involved in the origin of such domesticated plants as the potato, sugarcane, brome grass, cotton, tobacco, oats, apples, pears, and strawberries.

MUTATIONS

New, unpredictable heritable changes in plants may occur, known as gene mutations. Genes are invisible units of the chromosomes, each with a potentiality which may become expressed as an observable characteristic of a plant or animal. Ordinarily, genes are stable, remaining unchanged through many generations bridging millions of years. At the other extreme, there are genes that are unstable and mutate frequently in the same way. An illustration of this is found in a corn variety known as Variegated Pericarp or Calico. This maize variety is characterized by the pericarp of the grain being finely variegated with red stripes orientated lengthwise of the grain. Each red stripe or sector is the result of a mutation as shown by Emerson (1914, 1917) and studied recently by Anderson and Brink (1952). Occasionally grains were found which had an entirely red pericarp. The gene controlling the red color is stable, since, when red grains

are planted, every grain on the ear borne by the plant from the red grain is red. For about 10 years the writer has had a strain of Calico maize in culture for another purpose. During that time, four ears have been found, each with a block of grains with colorless pericarp (pl. 5, fig. 23). When these colorless-pericarp grains are planted, ears are borne, every grain of which is colorless. This may represent a mutation in the unstable gene to one that is stable as far as colorless pericarp is concerned.

Mutations may occur in the formation of gametes, or in any living vegetative or somatic cell. In vertebrate animals and in some plants, mutant cells in somatic or vegetative tissues are lost with the death of the individual or at least death of the organ in which it occurred. This has given rise to the too common notion that mutations only occur in the formation of gametes. No techniques are known at present by which pieces of somatic tissues or organs of vertebrate animals or the vegetative organs of some plants can be used in the propagation of such organisms. However, most seed plants may be propagated vegetatively from leaves, stems, or roots. A mutant cell in any one of these organs then has a chance of survival, providing the organ is placed in proper conditions which will lead to vegetative multiplication.

If a mutation occurs in a gamete or in the fertilized egg, every cell of the embryo is identical to the zygote, as far as chromosomes and genes are concerned. This continues to be true for all cells of the seedling as well as the mature plant. This was mentioned earlier when dealing with growth and development of maize zygotes. Ordinarily when this happens, the mutant individual may be found among many individuals of the parent type which do not exhibit the change. An example of such a mutant is illustrated by Ulrey's variegated African violet (*Saintpaulia*) (pl. 7, fig. 26). This variegation is due to a chlorophyll deficiency in the young leaves, and is gradually lost as the leaves become older, with old leaves often being entirely green. More variegated plants may grow vegetatively from leaf cuttings.

Previously it was mentioned that mutations may also occur in any vegetative or somatic cell. This may be illustrated by the African violet variety sold as "Orchid Wonder." The leaves of this variety are ordinarily dark green in color. The plant illustrated by figure 27 (pl. 7) grew vegetatively from the petiole of a detached leaf of the Orchid Wonder variety when placed in moist sand. The chlorophyll-deficient tissue resulted from a cell that mutated in the stem primordium which developed near the cut end of the petiole of the detached leaf. As the stem primordium grew, the mutant cell increased in numbers and the chlorophyll-deficient tissue became distributed in

many of the leaves seen in the illustration. Each varigated leaf then is made up of two genetically different tissues instead of one, as is usual. When variegated leaves of this African violet are used as propagules, the young plants are usually green, as typical of the original parent, or they are so chlorophyll-deficient that adequate sugar is not made and they soon die of starvation. The variegated state can be propagated from stem cuttings, but this is difficult and not practical since the internodes of the stem are very short and ordinarily there is only one terminal vegetative bud. The lateral or axillary buds ordinarily are inflorescence buds and their growth is determinate. Similar mutants have been observed in plants derived from leaf cuttings in varieties sold under the names "Mentor Boy," "Red Head Girl," and "White Lady." The same kind of mutation has probably occurred in many varieties of *Saintpaulia*.

In most variegated plants, the stem internodes are much longer than in *Saintpaulia*, and the axillary buds are more likely to be vegetative rather than reproductive. Examples of this will be recognized in the common varieties of geranium (*Pelargonium*) and *Coleus*. In such examples numerous *stem* cuttings may be made from a single plant. If these stem cuttings are chimaeras, then the chimaeral or variegated condition may be propagated. Mutant tissues in a chimaera may be distributed in a plant organ in one of three ways: (1) periclinal, (2) sectorial, and (3) mericlinal. The periclinal chimaeras are the most stable of the three types. This one is characterized by the mutant tissue forming a solid sheath about the whole organ. The red skin of a Red Triumph potato tuber (pl. 10, fig. 38, *A*, *B*) is an example. The sectorial type (pl. 10, fig. 39; pl. 11, fig. 40) is the least stable as far as the chimaeral condition is concerned. The mericlinal type is characterized by an uneven distribution of the mutant tissue in the organ, forming streaks, splotches, or mosaic patterns. The mericlinal type is less stable than the periclinal, but more permanent than the sectorial form. Most variegated ornamental plants fall in this class.

The variegated geranium (*Pelargonium*) listed as "Silver Leaf S. A. Nutt" (pl. 7, fig. 29) is a fairly stable chimaera exhibiting albino tissue about the border of the leaf blade. When branched plants are cut back and lateral buds are forced to develop, occasionally a stem is found which bears green leaves with no variegation (fig. 29). Less frequently an albino branch may develop laterally from a larger stem which bore typically variegated leaves. Cuttings from the green branch will multiply vegetatively and continue to be entirely green. Cuttings from the albino branch will not survive because of the lack of sugar.

Another variegated geranium (*Pelargonium*), variety "Mme. Solleroi," has a chlorophyll-deficient (yellow-green) area radiating from

the petiole-end into the leaf blade (pl. 7, fig. 28). This variegated condition ordinarily is quite stable. However, figure 28 illustrates a plant that has a completely green branch and one that is chlorophyll deficient, in addition to branches that have typically variegated leaves. Cuttings from the green branch will reproduce vegetatively, continuing to be green and presumably like the parent of this variegated variety. Cuttings from the mutant yellow-green branch will root and continue to grow with all new leaves and branches having the chlorophyll-deficient color. It is less vigorous and more care is necessary in keeping conditions right for growth.

The above two geraniums (Silver Leaf S. A. Nutt and Mme. Solleroi) illustrate how mutations occurring in vegetative parts may result in chimaeras. The mutation may have occurred but once many years ago, for each variety, and the mutant chimaeral or variegated state has been maintained by vegetative multiplication. Most variegated plant varieties may be used to demonstrate a mutant individual. The exceptions are found in some varieties that have genetic patterns characteristic of some *Coleus* varieties, and albino spots, blotches, or streaks due to viruses, as in *Abutilon pictum* (flowering maple). The geranium specimens illustrated in figures 28 and 29 (pl. 7) demonstrate vegetative or somatic segregation of the mutant tissue from the chimaera as well as segregation of the original type—the green branches. Obviously meiosis is not involved in this segregation, but is due to fortuitous anatomical deviations. For centuries man has been taking advantage of these vegetative or somatic segregates ("sports" of the older horticultural literature) without much of an understanding or appreciation of how they came about. It has been of great importance in obtaining new and useful plant varieties not only among ornamentals, but in most modern varieties of apples, pears, grapefruits, oranges, peaches, grapes, and many others.

An unnamed variegated *Coleus* variety, with leaves characterized by a dark-red background with flecks of yellow distributed without any particular order or constant pattern, was maintained in culture for several years. From one plant a branch developed which bore completely red leaves (pl. 8, fig. 30). Cuttings from this branch have continued to be dark red in color without any indication of yellow flecks. Figure 31 (pl. 8) is a photograph of a plant of the same variety exhibiting a yellow-leafed branch. The yellow branch propagated vegetatively, and continued to be entirely yellow with the characteristics of the commercial Golden Bedder variety. A third mutation was observed from the same unnamed variety and is illustrated by figure 32 (pl. 8). The mutant branch bore leaves which were red with a yellow border around the edge of the leaf blade. Several similar mutations resulting in chimaeras have been found in *Coleus*.

The vegetative or somatic segregation of mutant tissues from a chimaera often is not as readily accomplished as in geranium and *Coleus*. Special methods may have to be employed, as described below, for potato and *Sansevieria*. Some years ago it was noted that in the common potato variety "Red Triumph" tubers could be found which had irregular white areas surrounded by the usual red skin, as illustrated by *A* and *B* of figure 38 (pl. 10). This seemed to indicate that at least these particular tubers were chimaeras, usually of the periclinal type, but by some anatomical deviation the mericlinal form might develop, as shown for those with white areas in the skin. No bud that was free of the red pigment was found isolated in the white areas. Since the potato is propagated vegetatively from tuber cuttings having at least one "eye" or bud, it seemed probable that the red-skin character was transmitted to the new vegetative generation by the outermost layers of embryonic cells in the stem tip of the bud. To shorten a long story, the stem tips on numerous cuttings were "peeled" and planted. Some cuttings survived the peeling treatment and developed as usual-appearing potato plants, but were slower in sprouting. In late summer, when harvested, the tubers from most of the treated plants were all variegated, and were interpreted as being mericlinal chimaeras. These probably resulted from incomplete removal of all red tissue from the embryonic stem tip at the time of peeling. A few plants bore tubers all of which were *white* (pl. 10, fig. 38, *C*), including the "eyes" or stem tips. During the following summer, cuttings from the white tubers were planted, all of which developed plants bearing "White Triumph" potatoes. Two other varieties, "Blue Victor" and "Blue Meshanoc," have been treated in a similar way, resulting in a "White Victor" and a "White Meshanoc" potato.

Bowstring-hemp or snakeplant (*Sansevieria trifasciata*) (pl. 9, fig. 33) has been in cultivation as an ornamental for more than a century and as a fiber plant in Africa for a much longer time. About 50 years ago a variegated form, characterized by a golden-yellow border around the leaf edge, was found in cultivation by a native tribe in the Belgian Congo. It was named *Sansevieria trifasciata* var. *laurentii*, and is usually listed on the floral market as *S. laurentii* (pl. 9, fig. 34). This variety is more popular today as a decorative plant than is the species. The species (fig. 33) could propagate vegetatively from leaf cuttings as well as from rhizome pieces having a stem tip. Soon after the variegated variety (*laurentii*) was introduced as a house plant it was learned that the variegated form could be propagated only from rhizome cuttings. When leaves are used as propagules, nonvariegated plants will result which are like the species as illustrated in figure 35 (pl. 9). This led to the inference that *laurentii* is a chimaera with two genetically different tissues. That is, the golden-yellow tissue,

forming a border to the leaf, is genetically different from the green tissue. To test this inference, leaf cuttings were made as illustrated in figure 36 (pl. 9). This was done because roots develop from the cut end when in contact with moist sand. However, ordinarily roots develop only from the green tissue of the leaf cutting and not from the yellow tissue. New shoots or stems initiate at the base of a root about where the root originates from the leaf tissue. A block of all-green tissue was removed from the area of the leaf cutting that was to be set in moist sand, with only strips of yellow tissue in contact with the substrate. Roots, after some time, developed from the yellow tissue and eventually golden-yellow shoots as illustrated in figures 36 and 37 (pl. 9). At first the shoots are slightly green, indicating the presence of some chloroplasts, but these soon disintegrate and the tissues become golden yellow in color. If the rhizome connection between the yellow shoot and the leaf cutting is broken, the shoot dies of starvation within about 2 weeks. This is presented as evidence that the yellow tissue is genetically different from the green. The yellow tissue is mutant tissue that has existed in a chimaeral relationship with green *Sansevieria* tissue, perhaps much longer than the 50 years since the French botanist Laurent discovered it in cultivation by natives of the Belgian Congo. It is only by accident, or when special technique as described above is applied, that segregation of the pure yellow mutant tissue results in chlorophyll-deficient plants.

Mutations resulting in sectorial chimaeras may occur in leaves, stems, roots, inflorescences, flowers, and fruits. The grapefruit illustrated by figure 39 (pl. 10) had a relatively large sector of the fruit coat or pericarp that was dark brown in color in contrast to the light-yellow color of the remainder of this particular fruit. No differences were observed in the carpels containing the pulp opposite the brown sector of the pericarp and those opposite the yellow part of the fruit coat. The inference from this and other evidence was that only the sector of the pericarp was affected by this mutation and that the carpels and seeds opposite the brown sector were not changed. Similar sectoring is fairly frequent in oranges, lemons, and grapefruit.

Sectorial chimaeras in fruits are not always superficial, i. e., limited to the pericarp. Several years ago there was found in a field a tomato fruit of the Baltimore variety (pl. 11, fig. 40) that had a sharply outlined yellow sector with the adjoining parts a deep red color. Eventually a cross section of the fruit was made in order to examine the extent of the yellow mutant tissue of the sector. It was readily evident that the yellow tissue extended to the center of the fruit and included two seed cavities.

Seeds from the yellow sector were saved, as well as those from the red portion of the fruit. Three plants from seeds of the yellow sector

matured and bore yellow fruits (pl. 11, fig. 41). Descendants from these 3 plants have been carried through 10 generations with the matured fruits of each generation continuing to be yellow.

Seeds from the red portion of the chimaeral fruit (pl. 11, fig. 40) were also saved and planted. All the progeny bore red fruits. Two lines were selected from these red-fruited plants as sources of seed. Descendants of these two plants have been planted for 10 generations with no segregation of yellow fruits having been observed and no more fruits have been found with yellow sectors.

Yellow-fruiting plants were cross-pollinated with red-fruiting plants. The hybrid plants (F_1 generation) all bore red fruits, as might be anticipated from results upon crossing other varieties of red and yellow tomatoes, illustrating the dominance of the red color factor over yellow color. Seeds were obtained from self-pollinated hybrids and planted. Out of a group of 59 plants, 45 bore red fruits and 14 were yellow-fruited, working out as a simple Mendelian 3:1 ratio.

Although no other sectorial chimaera has been reported for fruits from which the mutant character is transmitted by seed, it probably does occur and usually escapes unnoticed. This suggests another plant organ and place in the life cycle worthy of close observations, where mutants may be discovered.

This story of the domestication of plants is a story of how man has and is now making use of the products of evolution that are desirable to him. The world is represented in our gardens, orchards, and fields by many domesticated plants necessary to our daily activities and well-being. Achievements have been considerable in the past, and there still remains a great reservoir of unexplored plant potentialities.

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The Scientific Detection of Crime[1]

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Every human society, even the least advanced, has been obliged, in the face of certain antisocial acts imperiling its very existence, to draw a distinction between lawful and unlawful conduct. The concept of crime and misdemeanor is thus inseparable from the concept of society itself, and the struggle against crime is a social necessity of overwhelming importance.

Although it may appear self-evident, this idea has not always been fully grasped, because it was overshadowed, for a long time, by religious considerations. All religious doctrines lay down moral laws, defining right and wrong and holding out the prospect of reward for virtue and punishment for evil. They correspond to the rules of social defense which are essential to community life. Parallel to religious rules, legislators have drawn up codes of behavior, listing legitimate acts on the one hand, and antisocial acts on the other, the latter being forbidden and subject to penalties varying according to the gravity of the offense.

In order to enforce the law, the first step is to discover the crime and then to trace the guilty party. This is the principal task of the judge or of the officer of the law responsible for establishing that an offense has been committed, for identifying the offender, collecting proof of his guilt, and discovering his motive. The file transmitted to the judge must contain the complete story of the crime and enable the judge to estimate the criminal's responsibility and inflict upon him the penalty provided for by the law.

Thus it is the examining magistrate—or his assistant, the policeman—who is the first to learn the facts of a crime. By making a systematic study of the conditions, circumstances, and environment in which the crime was committed, he manages to reconstruct the facts

[1] Reprinted by permission from Impact of Science on Society, vol. 4, No. 3, Autumn 1953, published by UNESCO.

as they occurred and discover the perpetrator. What methods does he employ, how have such methods been developed, and why do the police resort more and more frequently to modern scientific techniques?

METHODS OF JUDICIAL INQUIRY

Methods of judicial inquiry differ considerably, both in theory and practice, according to the legislation in force in each country; they fall, however, into two main categories, i. e., methods employed in Anglo-Saxon countries, and those employed in Latin and Germanic countries.

Accusatory procedure, which is the older, consists in bringing two adversaries face to face. Defendant and plaintiff debate the case, orally and publicly, in front of a judge or jury acting as an impartial arbitrator. No proceedings can take place without an accuser, and, when dealing with offenses under common law, the policeman is the public prosecutor; it is his duty to prove, resorting to all the means in his power, that a breach of the law has been committed.

Inquisitorial procedure, consisting of written and secret evidence, is entirely different. In this case, it is the magistrate himself who seeks for evidence and collects it in a file, which he then hands to the judge or jury responsible, in the last resort, for deciding whether the accused is guilty and what penalty should be imposed.

Accusatory procedure, most clearly described as a "judicial encounter," has, in almost every case, been the earliest to be adopted, and is still the main feature of the judicial proceedings of African tribes, where trial by ordeal, or "the judgment of God," still sometimes plays a vitally important part. In England, it remains the foundation of criminal procedure and explains the very nature of proceedings in English courts. Although it has reached a stage of perfection in that country, the Latin peoples do not find it sufficiently logical and, ever since the Roman Empire, they have preferred an inquisitorial system. After a short period of revival in France during the Middle Ages, accusatory procedure once again vanished and, since that time, the inquisitorial method has been employed, except in England, by all European countries.

Whatever the procedure adopted, however, the detection of crime is always based on the same principles. In order to punish an offender, after proving that there has been a breach of the law, evidence must be adduced, proving that a certain person is in fact the guilty party. All criminal procedure, whatever its nature, is thus based on a probative system; in administering justice, the truth is not discovered—it is proved.

For the collection of the necessary proof, the police officer relies on two methods complementary to each other, differing widely in nature and technique and whose relative importance has varied through the

centuries; the first consists of obtaining evidence from human witnesses, and the second of obtaining evidence by studying the facts.

Human testimony is obtained by examining the accused or witnesses; this is essential to any investigation, and explains why it is necessary to be a good psychologist in order to be a successful investigator. The report of the examination remains the cornerstone of the preliminary investigation; many writers have explained how it should be drawn up, and have worked out a set of rules, but they have also drawn attention to its shortcomings.

Evidence obtained from human witnesses has already been sufficiently criticized.[2] To seek for the truth in statements made by an accused person who cannot speak the truth without condemning himself is hazardous, to say the least. The same is true of the evidence given by his relatives, his children, or his servants; it is so true that it is forbidden by law to put them on oath before examining them. Although "the right to lie" may appear open to criticism, it is nevertheless a fact which has to be accepted, and the probative value of such statements is always very slight, or even nonexistent.

The same is true, though to a lesser extent, of most evidence given by human witnesses. Even a witness involved only by chance in a crime, and having nothing to gain by lying, may make mistakes, and often does. There are classical examples of the unreliability of memory, even in the case of recent events, showing how several people, all acting in good faith, may remember the same series of events differently. A witness's physical or mental condition may influence him without his being conscious of it, so that he sometimes distorts the facts beyond recognition. In addition, it is not unusual for an investigator to suggest untruthful replies by the manner in which he puts his questions. That is the danger of examining witnesses by means of leading questions, and such interrogations have been responsible for a great many false admissions.

The proof that an investigator is most anxious to obtain is the "final proof," that is to say, confession. With the inquisitorial system, if suspects refused to confess, the police used to resort to torture, although, as La Bruyère said: "It is a method calculated to lead an innocent man, of weak resistance, to the gallows and to enable a guilty man, with a strong constitution, to escape justice."

When public indignation led to the abolition of torture at the end of the eighteenth century, the only other known probative method was interrogation or examination.

[2] Any reader interested in this subject would do well to refer to L'Appréciation des Preuves en Justice, by F. Gorphe, Paris, 1947, which is a classic, and to the report presented by Dr. M. Cénac to the Fifty-ninth Congress of Mental Specialists in 1951.

In forming his own private judgment, the examining magistrate relies on such examination of the accused; he will obviously feel far more satisfied in his own mind when he has managed to obtain an actual confession; he can then conclude his investigation with a clear conscience.

Whatever the methods of criminal procedure or judicial inquiry employed, there is no disguising the fact that human evidence, in spite of its weaknesses, still is and will remain, at least for many years to come, one of the most important factors in any investigation. Later on, we shall see how efforts have recently been made to remove the arbitrary character of human evidence and reduce the possibilities of error by introducing scientific methods. Human evidence was so unreliable that it had to be supported by surer proof, and especially by the evidence of facts. In order to satisfy himself of the guilt of the accused, the investigator was obliged to seek conclusive evidence independent of human statements.

If he had not done so, the magistrate would have had no other choice than to replace the evidence extorted by torture—unreliable though it was—by his own subjective intuition and personal impressions, thus reverting to a primitive form of justice, more or less based on guesswork, which was precisely what has to be avoided. For the future of the probative system, it was thus essential to introduce scientific methods into criminal investigation.

INTRODUCTION OF SCIENTIFIC METHODS

The first science to be used in criminal investigation was forensic medicine. Very often, an examining magistrate learns far more from the medicolegal examination, or autopsy, than from all the evidence supplied by witnesses, because no witness can know exactly what only such an examination can reveal. It confirms or disproves the fact that rape has been committed, and reveals the existence of internal injuries, which are sometimes fatal but have been caused by blows leaving no external mark; or, on the contrary, it shows that a death, which at first appeared extremely suspicious, was in fact due to natural causes. A medical expert often establishes the causes of death beyond all doubt, describes the weapon used, the way in which it was employed, and the immediate or delayed effects of a wound. Nowadays, a criminal investigation failing to start with a postmortem examination would be inconceivable, and the law has quite rightly made an autopsy compulsory whenever permission to bury the body is withheld.

It is even more necessary to employ scientific methods in cases of poisoning, for it is obvious that a "chemical crime" is directly connected with chemical methods. Thus toxicology, a science dealing with accidental or intentional poisonings, came into being in the middle

of the nineteenth century and developed side by side with the chemical sciences. As a poisoning cannot be discovered unless the chemical substance employed by the criminal is identified, the only way of bringing the crime to light is to make a chemical analysis of the substance concerned. One of the earliest examples of the importance of chemical methods in criminal proceedings was the famous controversy which brought Orfila into conflict with his colleagues in the Lafarge case (1840); this controversy would never have arisen had the chemical methods used during the proceedings not been so ineffectual. Even in our own time, is it not true that disputes still arise between toxicologists, and are nearly always due to the imperfection of the scientific techniques employed? This goes to show how greatly the improvement of a scientific method in this field can further the cause of justice.

Up to 1880, the chemical crime, i. e., poisoning, was the only form of crime to which truly scientific methods were applied. Apart from the evidence supplied by the medical expert, the investigator relied solely on evidence given by human witnesses. Bertillon was the first to introduce factual evidence systematically into the detection of crime. At that time, and almost simultaneously in all European and American countries, it was at last realized that every criminal leaves behind him some tangible evidence of his crime, which, if correctly interpreted, may, independently of all human testimony, supply proof or circumstantial evidence of immense value. Such was the origin of scientific criminal investigation, i. e., forensic science, which has made steady progress during the past 50 years; there is a growing tendency to substitute it for verbal evidence or, at least, to have it reinforce the latter as effectively as possible.

SCIENTIFIC DETECTION OF FALSEHOODS

It was inevitable that the progress of scientific methods in the field of factual evidence should have repercussions on evidence given by human witnesses. As early as 1892, Ferri had advocated, in his Criminal Sociology, the use of hypnosis to "try out the reins and the heart" of a criminal and reveal his innermost thoughts. Lombroso used a sphygmograph to register a suspect's emotional reactions. Research on the possibility of detecting lies by testing a suspect's pulse, blood pressure, respiration, psychogalvanic reflex or electric reactions of the skin, etc., was carried out by Muensterberg in 1904, Marston in 1915, Larson and Vollmer in 1921, and Father Summers in 1932.

In the application of scientific methods to the interrogation of human witnesses, two very different lines have been followed. Under the first system, the aim is to suppress the consciousness of the individual being questioned, so that his subconscious may be freely explored. Although all methods based on hypnosis have failed, those involving

the use of artificial sleep have made great progress in the last few years; achievements in this field are, moreover, closely connected with those in the field of chemical synthesis. In the past 30 years, a constantly increasing number of hypnotics, producing an ever wider range of physiological reactions, have become available to doctors. The most recent barbiturics make it possible, before sending the subject off into a deep sleep, to keep him in a somnolent state, in which his consciousness is suppressed but his subconscious continues to function. While he is in this state, an individual can answer the questions put to him, but he can no longer control his replies; it is thus possible to obtain information from him which he would never have given, had he been fully conscious.

This method of questioning the subconscious is commonly used by psychiatrists in order to diagnose mental diseases accurately; it is called narcodiagnosis. It has also come to be employed, as "narcoanalysis," in forensic psychiatry, particularly for disclosing simulation. During such medical examinations, some subjects have confessed to crimes which they had committed, and this raises the question whether their confessions should be used in the course of the legal proceedings. This suggestion, however, has met with violent opposition, on the ground that the procedure involves a real "forcible entry" into the human personality; certain experiments, even in the medicolegal field, have aroused very strong feelings. All those who consider that the innermost recesses of the human mind are sacred and should not be tampered with are categorically opposed to this method.

This is not the place to raise the question whether the interests of society should not take precedence over those of the individual and whether the accused's right to lie should be respected. However, there is no doubt that narcointerrogation raises moral and social problems of prime importance and it would appear premature, at the present stage, to introduce it into criminal investigation.

Working on parallel lines, but without using hypnotic methods, other research workers have tried to obtain from suspects, who were fully conscious, replies of a kind enabling them to discover whether the subjects were lying or not. They apply the various physiological tests already mentioned, using a single apparatus, namely the polygraph or lie detector. The principle is to register simultaneously, on the same recording cylinder, the subject's physiological reactions while he is being asked very precise questions relating to the case at issue. The physiological tests applied are rhythm of breathing and heart beats, blood pressure, and electric resistance of the skin. The examination consists of a certain number of questions (not exceeding 15), some having no direct connection with the crime, and the others, on the contrary, being directly related to it. The subject must answer "Yes"

or "No" and, by comparing the physiological reactions to "pertinent" and "neutral" questions, it is possible to detect untruthful replies to the former.

It is quite obvious that, in this case, there is no "forcible entry" into the private recesses of the human personality. The subject is free to accept or refuse the tests; he is master of his own replies, and only his physiological reactions can betray him. If the test is to be of any value, there must be no coercion, and it has in fact never been suggested that there should be. Further, it should be noted that this method does not result in a definite confession, but leads to it indirectly by proving that the individual questioned has lied; the guilty party's ultimate confession is thus only a consequence of the test.

This form of interrogation with the help of a polygraph has been studied in particular by Prof. F. E. Inbau, of Northwestern University. In the United States of America today, some 60 police services and various private institutions, as well as the army, use Keeler's polygraph to detect falsehoods and test their employees. According to Keeler and Inbau, successful results have been achieved in over 80 percent of cases; it would thus appear to be an extremely effective test.

The use of this method has, however, given rise to a certain amount of criticism. Some particularly phlegmatic individuals do not show the normal reflexes when telling a lie. Others, on the other hand, are overemotional and the reflexes of these may be misinterpreted. However, no method of interrogation is infallible, and so far no apparatus which will guarantee 100 percent success can be conceived. It is nevertheless striking that even a thorough knowledge of the instrument does not enable an experienced subject to prevent it from betraying him. For example, a student who had had a great deal of experience of this apparatus was one day suspected of theft. Despite all the care which he took over lying and controlling his reactions, the polygraph detected his lies; it was subsequently proved by the investigation that he had, in fact, stolen.

Should the polygraph therefore now be employed generally in criminal investigation? There is no doubt that this instrument is particularly valuable from the standpoint of research. However, its employment calls for highly competent interrogators, and it does not seem that it can be put into general use before the latter have acquired the necessary experience.

In any case, the polygraph marks the introduction of purely scientific methods into the examination process—methods which will certainly end, one day, by transforming and simplifying it, while increasing its probative value. The past 20 years show, in this respect, an evolution parallel to that which, as we shall now see, has taken place in the realm of facts.

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THE BEGINNINGS OF FORENSIC SCIENCE—ANTHROPOMETRY

Conscience forbids our allowing an individual to be punished for an offense he has not committed. The first duty of the law is therefore to discover and identify the guilty party. The identification of the criminal is of still greater importance when there is any question of applying the laws regarding persistent offenders, which prescribe heavier penalties for other than first offenders.

There are thus two very different aspects of judicial identification. First, it is necessary to discover the person guilty of an offense, or, in other words, to prove that the person in question, and he alone, has committed it. Second, when a delinquent is thus convicted of a crime, it is necessary to investigate whether he has previously committed other offenses, in which event a heavier penalty would be entailed.

Bertillon was the first person to solve this problem and, from this point of view, must be considered a pioneer. Before 1885, there were no exact rules for the recognition of old offenders. The most usual method was to introduce prisoners in the pay of the police into the cells of the individuals suspected of having committed previous offenses, with the object of getting the suspects to talk and obtaining information from them, directly or indirectly, about their past life. Or else, if this method failed, another course open to the police was to parade the prisoners arrested the previous day, to see if they recognized any of them. If the latter denied accusations, it was impossible to prove that they were lying. In practice, all these methods failed in over 80 percent of cases.

People had, of course, already thought of using photography to identify criminals; and as early as 1854 an examining magistrate in Lausanne succeeded in having a dangerous criminal arrested in the Grand Duchy of Baden by circulating a daguerreotype of the "wanted" man through all the Swiss cantons and the adjacent countries; but such cases were the exception rather than the rule. The introduction of gelatinobromide plates and papers, which made it easier to obtain negatives and to print copies, enabled certain police departments to build up photograph albums of portraits of criminals known to the police, in order to facilitate their subsequent recognition. Experience showed that the desired aim was seldom achieved, for the very simple reason that, though it was easy enough to build up files of photographs of all persons arrested or convicted of an offense, it was impracticable to trace such persons in the files.

It was, in fact, impossible to devise a systematic method of filing these photographs so that the individual sought could be found by a gradual process of elimination. The more photographs that were added, the more difficult the problem became; and despite all its apparent advantages, the system had to be dropped. Bertillon himself later tried to develop a suitable filing system, but he, too, failed.

When however, in France, the Law of 27 May 1885 introduced transportation as an additional penalty for certain persistent offenders, it became urgently necessary to find a more satisfactory solution. Since 1878, Bertillon, a clerk at the Préfecture de Police, had been responsible for filing the cards of persons already convicted. He had been struck by the poor and unsatisfactory means employed for that purpose, and set out to find a solution for the problem.

Very often advances in a science are achieved by people who are not primarily concerned with that science. Pasteur was a chemist and mineralogist, but it was his discoveries in the field of medicine that immortalized him. Bertillon was not a policeman but, by training, background, and heredity, an anthropologist. His father, grandfather, and brother did anthropological work. It was the time when Broca's school was at its prime. Throughout his youth, Bertillon had associated with the foremost anthropologists in France and Europe; with these he had discussed the value of anthropological measurements, and he was familiar with them all. It is therefore not surprising that he should have thought of applying these methods—accurate methods based on exact measurements—to the solution of a problem that appeared to have no connection with them.

To identify anyone is to establish a relationship between a given individual and certain morphological characteristics observed in that individual. But these morphological characteristics must satisfy certain imperative conditions, having regard to the aim in view. They must be absolutely stable throughout the life of the individual; they must, at the same time, be as specific as possible, i. e., the group of characteristics found in any given individual must be found only in that individual and in no other. Lastly, they must be easy to record, with the use of simple equipment and elementary methods.

Bertillon approached the question as an anthropologist and, in developing his method, selected the forms of measurement with which he was familiar. The only anthropometric measurements that can easily be taken from a living being with sufficient accuracy are the dimensions of the bones. He therefore chose bone measurements, although they did not fully satisfy the two conditions mentioned above. They are not absolutely stable throughout life, and they change until the process of growth is completed. Secondly, they are not strictly specific, even when considered in combination. Our department has come across certain twins whose measurements were, as nearly as could be measured, exactly the same.

Despite these drawbacks, Bertillon succeeded in assembling on a single card a collection of bone measurements distinguishing any given individual. At the same time, he worked out a method of filing which enabled him unerringly to trace the individual for whom he was looking from among the hundreds of thousands of cards accumulated.

He reduced the inherent disadvantages of bone measurements by adding to the purely anthropometric details a note of any distinguishing marks, such as warts, scars, tattooing, etc., which are highly individual when their exact situation, size, and direction are clearly indicated.

Bertillon's method was strikingly successful. For the first time, thanks to accurate scientific methods, it was possible to refute the lies of an old offender who denied his previous misdeeds and, irrespective of what he said, to establish his true identity. Despite the difficulties involved, and the complexity of the method, it spread all over the globe in a few years, and by 1895 most police forces throughout the world were using the Bertillon system.

FINGERPRINTS

But a formidable competitor was soon to oust Bertillon's system. The work of Galton in England, following that of Sir William Herschell, Faulds, and Vucetich, had established that fingerprints could very well take the place of bone measurements. The system of ridges in the skin, forming regular lines all over the inside of the fingers, the palms of the hands, and the balls of the feet, proved to be infinitely better, for the purpose in view, than any other morphological feature. Experience over a period of more than 70 years has shown that the system is absolutely stable, not only throughout life but before birth, from the fourth month of the mother's pregnancy, and after death, until the total destruction of the skin. All police forces throughout the world have identified drowned bodies found several days or sometimes weeks after death, by removing the saturated epidermis and taking prints from the exposed ridges in the corium. The probative value of fingerprints as evidence in the identification of human beings is universally recognized.

A few years ago, however, some anxiety arose. L. Ribeiro had observed that in leprosy, in which trophic disturbances usually affect the extremities, progressive changes took place in the ridge patterns, sometimes almost totally obliterating them. The same series of observations established, however, that if the disease was treated and an improvement set in as a consequence, if the trophic disorders were brought to an end, the ridge patterns returned in exactly the same form as they were before the illness.

It still had to be proved that in no case were there two identical fingerprints. Admittedly, when we examine fingerprints, we see that there are only a few general patterns—four or five at the most. When, however, we go into the details of the ridge system, we very soon find that there are always differences in the morphology of the patterns, by which one can be infallibly distinguished from another.

In point of fact, despite the countless comparisons of fingerprints which have been made by experts throughout the world for more than

50 years past, no two identical prints have ever been discovered. Experience, in this case, has confirmed theoretical calculation.

When a fingerprint is examined in detail, it will be seen that it is made up of a series of ridges and depressions, running parallel to one another and arranged more or less regularly around a central point roughly in the center of the fleshy pad. These ridges form either more or less flattened arches, or loops, opening to the right or left, or, again, more or less complicated whorls. At the base of the finger, there is a system of ridges roughly parallel to the line at the joint. The meeting place of this system and the other is formed by triangular points in the shape of a Greek "delta," by which name they are, incidentally, known.

These papillary ridges are not absolutely regular, however; in some cases, they are broken and end abruptly; in others, they split in two; in yet others, they form islands between two longer ridges. Each of these irregularities is useful for identification purposes. Taking their presence and position in the print as a basis, Balthazard, by a simple calculation of probabilities, has shown that approximately 1,074 million prints would have to be examined to find two prints showing 15 points of coincidence in the ending of their lines or their bifurcations.

The first joint of one finger alone contains more than 100 of these identification points. One finger can therefore definitely reveal the identity of an individual, and indeed a portion of a print may be enough. The whole system of fingerprints is based on this principle.

Lastly, a fingerprint is extremely easy to take. All that is needed is a plate covered with ink on which the finger can be rolled. Fingerprints are thus the ideal morphological characteristic for identifying individuals; throughout the world, they have taken the place of Bertillon's bone measurements, which are now of no more than historical interest.

It is not enough, however, to have found the ideal morphological characteristic; it must also be suitable for use in a card index system and for the tracing of cards. Several methods are used; in the English-speaking countries, they are derived from the Galton-Henry system and in the Latin countries from the Vucetich system. All these systems use the basic ridge patterns of the fingertips and differ in their methods of secondary classifications. Prints are traced by going through the files themselves.

It might be thought that no further progress could be made in such a field; and indeed the largest filing systems, sometimes including several tens of millions of cards, are entirely satisfactory. Nonetheless, a mathematical study of the problem of tracing an object with rather indeterminate characteristics among a group of similar objects has recently made possible a considerable improvement in the tracing technique, thanks to the use of a supplementary card index made up of

perforated cards. Efficiency is, as a result, several thousand times greater than before. A search which used to take several hours can be completed in a few minutes. This system has been developed entirely by mathematical reasoning based on the theory of sets, though a large number of statistical calculations with computing machines were also necessary. It is a very clear and recent example of the advantages of using a scientific method, in this case associated with a complicated branch of mathematics, in what seemed to be a totally unrelated field.

Before leaving this matter, we must point out that it is impossible for the police to trace an individual in a big 10-finger filing system, when they have only more or less perfect prints of one, or even two or three of his fingers. At the scene of a crime or a burglary, fingerprints are very often found on objects that the criminal has handled, and most people believe that the perpetrator of the crime can be identified, by reference to these prints, simply by looking through the files. This is not so. If an individual is to be found in a big 10-finger filing system, we must have prints of all 10 fingers. On the other hand, to identify a finger which has touched a glass and left a print on it, one has simply to compare the print and the finger; very often the identification is a mere formality. For this to be feasible, however, we must suspect a particular individual and have his fingerprint card. Comparison of each of the prints on the card with that found at the scene of the crime will enable us to say whether the latter was made by one of the fingers on the card. There are also single-finger filing systems from which, in certain cases, an offender can be traced by the ridge marks he may have left at the scene of the crime.

PHOTOGRAPHY

Criminals leave behind them not only their fingerprints but also many other material traces which, if properly collected, studied, and interpreted, may enable us to reconstruct events exactly as they happened and to identify the person responsible. This principle is the very foundation of scientific detection, and the first function of this science is to discover such traces and study them in the laboratory, in order that they may be used in evidence.

First and foremost, the state of the scene of the crime immediately after the event must be permanently recorded, and for this purpose photography is naturally used. The importance of the documentary evidence thus obtained is well illustrated by the following example.

A murder is committed, the victim being killed by two bullets in the head. Our service is not informed until the following day, when it takes photographs of the scene of the crime. No trace of a bullet can be seen. A week later, in company with the examining magistrate,

the men of our service work out from the prints the various stages in the tragedy, determining how the murderer fired the two shots. They return to the scene of the crime a few days afterward to complete their observations and draw a full plan. They then note, on one of the photographs taken that day, that there is, in the room in which the tragedy occurred, a chair which had not previously been there. On that chair, which had been deliberately removed immediately after the murder, they find traces of the passage of a projectile. These marks make it possible to show that the murderer's statements during the reconstruction of the crime were untrue, and to establish how the events actually occurred.

The scene of a crime cannot, however, be photographed in the same way as for ordinary purposes; and ordinary cameras are quite inadequate. The scenes of crimes vary so much, are so differently lighted, and so different in size, that photographers and camera manufacturers have to satisfy unusual and sometimes conflicting demands. The need to use the photographs, or some of them, as evidence at a later date makes it essential that all the details shall be sufficiently clearly defined to allow of considerable enlargement.

All advances in the technique of lighting make the work of the police easier; and the development of suitable cameras and lenses gives rise to very complicated problems. Difficult research has been necessary to obtain lenses with an angle of field greater than 90°, an adequate relative aperture, and a suitable depth of field.

If the photographic document is to do all that is required of it, we must be able, with its help, to reconstruct the dimensions of the objects shown in it. Since 1903, when Bertillon first devised a camera and a method of reconstruction intended for use at the scene of crimes, several not entirely satisfactory ways of solving this problem have been suggested. It was never fully solved until the progress of stereophotogrammetry furnished the photographer with cameras and plotting devices suitable for detective work. The Swiss police are equipped with stereophotogrammeters and automatic plotting devices (autographs); these are extremely useful, particularly in cases of motor accidents, for they make it possible, with only two photographs, to reconstruct a complete plan of the scene, showing measurements, the position of the vehicles, any marks on the ground, etc.

Even without using complicated and expensive autographs, it is possible, by more or less simple methods of geometrical reconstruction, to work out the measurements of traces found on the ground or on walls.

The author of an advertising leaflet reproduced in it a photograph of a building and he claimed that it was a nursing home in which he cured cancer by a special method of his own. On the façade of the building, there was an enormous inscription confirming his claim.

Was the picture faked and had the inscription been added to the negative for propaganda purposes? The perspective naturally altered the shape of the house, and direct examination of the inscription told nothing. It was therefore necessary to plot the inscription as it would have appeared if it had been painted on a surface parallel to the photographic plate. This was done by geometric methods and it was then found, in enlargements, that the letters were so arranged that no painter could ever have done the work. The photograph was therefore faked, and there had been no such inscription on the building at the time it was photographed.

In certain exceptional cases, photographic conditions are such that aerial photography has to be employed. This is particularly useful in the case of large-scale disturbances on the public highway.

Lastly, the development of motion pictures was bound to lead scientific police investigators to try to adapt this technique to the recording of particulars at the scene of the event. The first pictures of this type were probably made in Brazil. While their usefulness may seem questionable when it is simply a case of noting facts, they are undoubtedly a great help in the reconstruction of events where the investigator is faced with several different possibilities. This system has not yet come into general use, but there is no doubt that its advantages will one day be acknowledged to outweigh its drawbacks, the most material of which is the difficulty of showing a film in court.

DEVELOPMENT OF METHODS OF SCIENTIFIC DETECTION—A FEW EXAMPLES

It is impossible, in this article, to give a detailed account of the present methods used in scientific detection. In any case, it is preferable to show how they have developed and to indicate in a certain number of cases, by actual examples, how they have been evolved and how the pure and applied sciences have helped.

First and foremost, we must emphasize the need for the forensic scientist to adapt the methods of pure science to the particular aim he has to achieve. Forensic science investigations, indeed, involve a number of requirements, some of which are very exacting, regarding the quantity of a substance to be analyzed, the time taken for the analysis, or even the conditions in which the analysis itself is conducted. These requirements must be observed and the methods of pure science and technology, which have been developed to meet quite different purposes, must be adapted accordingly.

One of the most typical examples of the application of the latest scientific methods in the forensic field is that of the discovery of arsenic administered with criminal intent. As we have already mentioned, chemical methods developed during the second half of the nineteenth

century and improved at the beginning of the twentieth are giving more and more reliable results. Sensitive as these methods are, however, they all necessitate the taking of fairly large samples from the organs. It is known that arsenic tends to accumulate in the hair and nails; the quantity of arsenic found in a tuft of hair, at a given point, enables us to ascertain the time when the poison was administered, since we know the speed at which the hair grows (slightly over half an inch in a month). The chemical methods previously available, however, necessitated considerable quantities of hair, from half an inch to a few inches long, and therefore covering a period of one or more months. The development of atomic piles has now provided toxicologists with a neat and infinitely more accurate means of tracing acute or chronic arsenical poisoning. This method, as described by Griffon and Barbaud, consists in rendering the arsenic contained in the substance of the hair itself artificially radioactive by exposing the hair to the flux of thermic neutrons produced by an atomic pile. Subsequent analysis of the radiation from the hair enables us, first, to identify the element by measuring its period and, second, to determine its situation in relation to the length of the hair. It is thus possible, without in any way damaging the sample taken from the living or the dead body, to ascertain the date at which the poison was absorbed, and to trace the course of its impregnation of the organism.

Such developments are very common in forensic science investigation. We have been able to identify blood for a long time past; but since microspectroscopes have been introduced and improved, we have been able to identify extremely small quantities (much less than a milligram) with absolute certainty. It is useful, of course, to know that a stain has been made by human blood, but that does not tell us whose blood it is. Is it possible to discover individual characteristics in the blood by which we can answer this question? The research done, over the past 15 years, on blood groups has been the first step toward the solution of this problem. When these methods are applied to dry bloodstains, they help us to decide whether a stain found on the clothing of an accused person may have come from the victim or from the accused himself.

The research done on the theory of blood groups in human beings has revealed an ever-increasing number of specific factors in the blood, which are inherited according to Mendelian laws. Up to last year, the only blood groups covered by the methods of investigation used on dry bloodstains were the classic A, B, and O groups. Quite recently, similar methods have been applied to the Rh factor, and there is little doubt that in future they will be applied in many other ways.

When scientific methods are introduced, the provisions of a penal or a civil code, drawn up at a time when such ideas were entirely un-

known, may become outdated. For instance, under the Code Civil, in France at least, it was strictly laid down that only five types of evidence could be admitted in an action for affiliation. Judges, however, have become aware of the progress of research on blood groups and more and more often call for evidence on that point, the importance of which is increasing daily as the number of blood groups known to us extends and the possibility of ruling out paternity becomes more definite.

The social implications of this development can clearly be seen. In certain countries, such as Germany, affiliation does not entail the obligations imposed by French law. The child, for instance, does not bear its father's name or have a claim to share in the inheritance of his estate. In France, on the other hand, a child thus recognized enjoys all the rights of legitimate children. The extension of scientific proofs may therefore have important social implications from the point of view of the father or mother as well as from that of the child. We have come across actions for affiliation in which two men claimed to be the father of the same child.

So far, blood groups have been used mainly to rule out the possibility of a man's being the father of a child. That is the only case in which the blood group provides definite proof. Research is proceeding so fast, however, that it is to be expected that it will one day be possible to state a presumption of paternity with a relatively small percentage of error. Many young men will then have to reckon with the social implications of such actions, and the laws may possibly have to be altered as a result.

The same development can be seen in the detection of other stains of biological origin, such as semen, saliva, urine, and body fluids of all sorts. One of the main difficulties confronting a scientific investigator in the study of such stains is that of discovering them in the first place. There was absolutely no means of detecting them with certainty on a thick, colored material until the Wood ultraviolet lamp, with its nickel glass filter, made it easy to detect the fluorescence of the stains and to carry out the necessary histological or chemical tests on the stained portions only. The substances are later identified by the classic techniques of histology, pathological anatomy, and immunology.

These same methods may be applied to all animal and vegetable remains (such as wood fragments, scraps of plants or seeds, pollen, etc.) which may be discovered in dust. Every advance in these sciences makes it easier to carry out this particularly difficult type of identification. Even bacteriology may be called into play, and the following case affords a typical example.

After a big robbery, searches were made at the homes of various suspect individuals and bank notes were seized from several of these

people. Expert examination showed that all these notes looked the same, having the same unusual patches of fluorescence and similar rust stains. Moreover, examination of their microscopic flora showed that the same bacteria and fungoid growths were present on all of them; in particular, all were considerably affected by a rare and highly individual fungus, *Acrostalagmus cinnabarinus corda.* The flora on other notes kept in bundles or put into circulation was quite different. It was thus possible to prove the common origin of the notes and to confirm the complicity of the receivers.

The advances of science do not always, however, make the expert's task easier. Sometimes they make it much more complicated. We may have a police laboratory which is perfectly familiar with the methods of studying the usual textiles. Its members may be expert in comparing the fibers of wool, cotton, silk, jute, hemp, linen, etc. But the introduction of many synthetic textile fibers, to which the familiar techniques can no longer be applied, raises new problems which are sometimes extremely difficult to solve. The same is true of artificial dyestuffs, the number of which is increasing daily, and of the countless pharmaceutical products, some of which are dangerous narcotics, capable of being used instead of the derivatives of opium or coca. Their identification involves knowledge not only of their formula and chemical properties but also of the methods of organic chemistry by which their chemical functions can be determined and identified.

One of the most striking features of this development in methods is the substitution, for visual examination, of more complicated but also more efficient techniques. For a long time, materials, textiles, fibers, threads, animal and vegetable remains and dust were examined by means of the magnifying glass and the microscope. But such visual examination, and the interpretation of what is seen, necessarily depend on the observer. Whenever it is possible to use a physical or chemical method instead of, or to supplement, visual observation, greater precision and certainty are ensured. Mineral dust, earth, and mud can be identified under the microscope; and the use of a polarizing microscope is in itself a great step forward. Lastly, the methods of mineralogical analysis—separation by increasing densities, thermal analysis by the methods of Saladin and Le Châtelier, or even the determination of the magnetic moment—are still more efficient. More recently, X-ray spectrography, by which crystalline structure can be determined, and the electronic microscope with very high resolving power have been used with great success in the identification of dusts.

In the past, the only means of studying bones was by histological examination, which revealed changes attributable to fossilization. Fossilization can be followed still more accurately by means of chemical analysis and, more particularly, by the quantity of fluorine which,

in bony carbonate-apatites, gradually replaces the phosphoric acid of the phosphates. Finally, our knowledge of isotopes has very recently made an extremely useful contribution to the study of fossilization by means of the quantity of the radioactive carbon isotope (C_{14}) in the carbonates of the bones. During life, the proportion of radioactive carbon in the bones (as, incidentally, in plants) is the same as in the carbon dioxide in the atmosphere. After death, and when the body is buried in the ground, this radioactive carbon spontaneously disintegrates, half of it disappearing in about 5,600 years. By determining the remaining radioactivity of a fossil bone, therefore, we can date it with a very close approximation to accuracy. The amount of C_{14} in the wood of the funeral barge of Sesostris, for instance, which was thought to be 3,792 years old (to within 50 years either way), made it possible to establish that the barge was approximately 3,700 years old.

When a tiny fragment of paint from a broken door is found on a burglar's jimmy, we have, if we are to establish definitely that the jimmy in question was actually in contact with the door it was used to break open, to make a comparative analysis of the scrap of paint on the jimmy and the paint on the door. Microscopic examination is of no use in this case, the only valid proof being the identification of the paint's ingredients. Unfortunately, the qualitative composition of most ordinary paints is very similar. Quantitative analysis is therefore necessary, sometimes on a sample weighing only a few tenths of a milligram. Spectrography is the only possible means we can use, and even that must be conducted under very strict control.

The expert examination of works of art is much in the public eye. Police laboratories are more and more often consulted during judicial inquiries to establish whether or not such works are genuine. The increasing number of forgeries, the skill with which they are made, and the threat they constitute to our artistic heritage, necessitate the use of more and more complicated techniques for their detection.

It is exceedingly difficult to give an expert opinion on a piece of furniture. There may be, for instance, a Louis XV bureau with carved bronze ornaments, which is apparently of very great value. How can we establish whether or not it is faked? Analysis of the bronze ornaments shows that they are gilded by the mercury process commonly used in the eighteenth century, and so worked that the piece cannot possibly be a modern copy. Examination of the wood establishes that it is old and also dates from about the same period; certain later sections have been given an artificial patina. But this wood had already been used before being incorporated in the bureau, and was cut to fit the latter by means of a power saw. The piece is therefore a copy but an old copy, probably dating from the First Empire.

Or we may have a large glazed terracotta panel, attributed to Andrea della Robbia; if it is genuine it is a real museum piece. Expert

examination shows, however, that the clay of which it is made is a coarse clay containing much more iron than the clays used in making artistic terracottas. The pigments used are indeed the same as those employed by the fifteenth-century artists, but the same ones are still used today. The patina is artificial, being produced by a varnish with a basis of linseed oil, ochre, and verdigris. Finally, the panel has been broken and restored, but the restoration was done when it was still new and was strengthened by iron bars, one being made of rolled iron. But rolled iron dates from 1850 and the panel is therefore a recent forgery.

The works of art most often forged are paintings, and a wide variety of photographic and radiographic methods have to be used in their expert examination. Repainting is shown up by ultraviolet or infrared light; X-ray photographs, for which rays of low penetrating power are used, are a still better means of discovering traces of earlier painting beneath a later layer. Pigments can be identified by microchemical and spectrographic analysis and, as we know the dates at which they were introduced and ceased to be used in the last 10 centuries, they give us an invaluable means of dating certain works of art.

Arson is also difficult to detect. It is, as may be imagined, extremely hard to discover the substance left by the criminal in a mass of cinders and charred fragments, especially as such substances are highly inflammable. There may, for instance, be phosphates resulting from the combustion of a phosphorus bomb, the ashes of straw used to light the fire, or traces of oil or petrol scattered about the premises. All the processes of chemical analysis are then called into play, the main difficulty being to isolate the incendiary material from the ordinary residue of combustion.

Optical methods.—Scientific detection was, at the outset, a science of observation, supplemented by photography. Bullets and cartridge cases can thus be identified, footprints, signs of housebreaking, and tire marks compared, and forgeries on documents, identity cards, postage stamps, etc., detected. Every improvement in these photographic methods means a step forward. One of the most spectacular dates from the use of the Wood lamp, already mentioned, which provokes fluorescence in a large number of substances. Under the Wood lamp, obliterations in manuscripts are revealed, as well as writing in invisible ink, and gums and waxes of differing compositions can easily be distinguished. The colors of counterfeit postage stamps, or even the gum applied to them, can be distinguished from genuine colors or gums. Infrared photography also often shows up things that are invisible to the eye, such as the scorch marks around a hole caused by a shot fired through a piece of black clothing at close range.

About 20 years ago, manufacturers of photographic plates began to produce emulsions of varying degrees of chromatic sensitivity,

covering the whole spectrum. By using colored screens it is thus possible to take the colors out of an object; the slightest cancellation mark on a stamp that has already been used is then clearly revealed. Here again, advances in physics have affected criminal investigation.

We are now able to make screens by which the 2,500-Angström band of mercury in the ultraviolet can be isolated. Photographs of objects taken in this light reveal certain details which are otherwise invisible. As regards infrared light, the electronic telescope—an improvement upon the image-converting cell developed during the war to enable fighting forces to see at nighttime their opponents lit up by infrared light which is invisible to the human eye—has quite recently been adapted in Belgium for use in forensic science investigation.

Some objects whose surface needs to be photographed reflect light so strongly that it is impossible to photograph them directly. This applies to carbon papers that have been used in typing a document. Their shiny surface is dulled where the characters of the machine have struck the paper. When we try to photograph them, however, we find it impossible because of the reflection, particularly as they are very often crumpled. It is necessary to incline the surface at an angle to the axis of the lens so that the reflection is eliminated. The resulting photographs are distorted, however, and the original can be reconstructed only if we know the angle of inclination of the document; incidentally, the angle cannot be chosen haphazardly but must be calculated mathematically beforehand.

The trichromatic selection of colors on which color printing is based is far from perfect. It is very often impossible to cancel out a color completely, especially when it contains white or black, which is generally the case. It is still less possible to eliminate black characters on a colored background by photographic means, but it can in fact be done by the process described as "superimposing positives and negatives," as the following example shows.

A registered letter is handed in to a post office bearing stamps already canceled but with the postmarks almost invisible. In order to insure that these marks are not discovered, the post office clerk, who is involved in the fraud, stamps several times over each of the stamps. How can we discover whether, when the envelope was put into the post, the stamps were or were not already postmarked? The colors of the stamps can easily be screened out by a simple selection of colors, leaving only the postmarks; but, even in enlargements, it is impossible to discern whether or not there are other marks from different stampings among the stamp marks of the dispatching office. In such a case, we may photograph on transparent films: (a) the stamp of the dispatching office as a positive; (b) the postmarks on the stamps

as a negative. We may then superimpose the positive and negative exactly and, if the values of the whites and blacks are exactly the same on the positive and the negative, the whites will compensate the blacks and vice versa. If we then make a print through these superimposed films, all that will show are the canceling marks not belonging to the dispatching office. It is thus possible not only to detect these traces, but partially to decipher them, and so discover the office responsible for the first cancelation.

This method, which theoretically is very simple, is in practice extremely difficult to use, for the perfect compensation of the whites and blacks presents us with a problem of photographic photometry whose difficulties are well known.

The study of written documents is still more difficult. Any treatise on scientific detection, even of recent date, will show how scanty the means employed by the experts are. They generally consist simply of examination under the microscope and the application of a few chemical reagents. More accurate methods exist, but they are much more difficult to use and involve a full-scale physical laboratory. For instance, the mineral constituents or, indeed, in some cases, mineral impurities in ink can easily be identified by spectrography. Spectrophotometric analysis of the pigments in inks enables one ink to be compared with another; indeed, a method of photographic photometry has been invented that can be used directly by reflection on the document itself. It is easy to determine the amount of iron in inks once it has been transformed into a colored compound. Variations in the amount of iron in inks containing logwood dyes are particularly significant, as these inks do not normally contain this product.

It seems probable, however, that the best methods of identifying and comparing the pigments in inks are chromatography on alumina, selective chromatography on paper, and microelectrophoresis on paper, the last of which is still being tested in my laboratory. By these methods, with only one word as a test basis, the pigments in inks can be distinguished and their impurities revealed. Here, again, however, progress has complicated the expert's work. The inks used in ball-point pens are very different from the earlier ones and cannot be analyzed by the same methods. As a result of their introduction, therefore, the expert finds new problems facing him, and new methods have had to be devised to solve them.

Examination of firearms.—There have been similar developments with regard to firearms. Scrutiny under the magnifying glass or the microscope is still the main means of identifying bullets and cartridge cases; but we are now able to analyze, by chemical means, the traces of powder and its combustion products in the barrel of a gun or around the hole made by a projectile. Quantitative spectrography or

microchemical analysis enable us to detect, in such holes, the few thousandths of a milligram of metal left behind by the bullet as it passes through the material. When this degree of accuracy is called for, absolute reliability in the physical or chemical methods used is essential. A microchemical reaction of mercury, for instance, which is very specific, will detect less than one-millionth of a milligram of mercury. By this means we can trace the mercury derived from the fulminate of a cartridge cap to a distance of more than 30 inches from the mouth of the barrel of a weapon. The following is a very interesting instance of the use of this method.

A man is found dead in bed with two bullet wounds—one in the heart, from which he must have died almost immediately, and the other a mere flesh wound in the abdomen. The weapon lies at the foot of the bed, the last cartridge fired being jammed in the ejection opening; the other cartridge is found on the ground. The first investigators, when collecting the cartridges, have mixed them up so that it is no longer possible to say which was jammed in the weapon and was therefore the last fired. The two bullets are found during the autopsy and it is easy to determine which came from which cartridge case, since one is of American and the other of Belgian manufacture. What the investigators have to determine, however, is the order in which the two shots were fired. In the case of a suicide, the fatal shot could only be the second; if the fatal shot was the first, it was obviously not a case of suicide, since the man could hardly kill himself before wounding himself.

In an attempt to identify the cartridge first fired, we investigated the mercury in the barrel of the weapon. As we have just said, one of the cartridges was of American origin, and we verified that the cartridge caps of this type of ammunition were made of lead nitride. The other cartridge, which was of Belgian make, had a fulminate of mercury cap. Comparative experiments showed that, if two shots were fired from the same weapon, using one cartridge with a lead nitride cap and one with a fulminate of mercury cap, the quantity of mercury found in the barrel was much greater when the fulminate cartridge was fired last. We were thus able to reconstruct what had happened and to show that the fatal shot was indeed the first, so that suicide was almost excluded.

We could quote many other examples. The one we have given shows that we should always try to solve a scientific problem of detection, even when it seems insoluble, so long as a sufficiently sensitive and specific method of analysis is available.

In the scientific detection of crime, we are therefore constantly on the lookout for new methods developed in pure science laboratories.

It may with good reason be said that the development of a new technique, such as chromatography, may offer the forensic scientist unsuspected opportunities.

THE SOCIAL VALUE OF SCIENTIFIC CRIMINAL INVESTIGATION

For a magistrate enlisting the services of an expert, there is one question of overriding importance: how far can he rely on scientific evidence? His knowledge of science being naturally limited, he cannot estimate the reliability of such evidence, and the disputes that sometimes arise between experts lead him to adopt a cautious attitude.

Scientific criminal investigation produces absolute proof only in certain special cases, such as that of fingerprints; the exact value of this form of evidence can be worked out mathematically. Generally, however, this is not so.

What forensic science methods contribute to court proceedings is circumstantial evidence, often very conclusive, and, in a great many cases, sufficient to elicit a confession. Such a confession, which salves the judge's conscience, is far more valuable than any obtained in the course of an interrogation. It proceeds from a sequence of irrefutable facts, which enmesh the accused and leave him no loophole. Even when the circumstantial evidence produced by an expert does not elicit a confession, it is sufficiently precise to enable the value of the charges brought against the accused, or the facts militating in his favor, to be weighed with considerable accuracy. The ideal system, of course, would be to express that value in mathematical terms, as is done for fingerprints. That is possible only in a few cases, but it is to be hoped that their number will increase as forensic science methods improve.

There is no doubt that the introduction of more and more accurate methods in the detection of crime makes for greater certainty in the administration of justice. The social importance of these methods is therefore clear.

Crime represents a threat to man's safety in communal life, and everything that facilitates the discovery and punishment of crime affects that safety. The introduction of scientific methods is therefore directly connected with the protection of society, and any method that adds to the resources at society's disposal influences the outcome of the struggle. Society's fight against the criminal classes may be compared to a war between two states. If one of them has greater scientific resources, it can be sure of superiority over its enemy; the same applies to the struggle against crime, and this social aspect of the question is indeed so clear that it seems unnecessary to dwell on it longer.

We may ask, therefore, whether the increasing armory of scientific resources commanded by society in this struggle influences the spread or the reduction of crime.

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Such an influence is obvious in a few special cases. The progress of toxicology has certainly played a great part in reducing the number of poison cases. Although we have no exact statistics going back several centuries, it is probable that poisoning was once much more common than it is at present. In our time, it rarely occurs except among the less civilized sections of the population, or in country districts. The merest suspicion of poisoning will cause it to be brought to light.

On the other hand, such social repercussions are less certain where other types of crime are concerned. The seriousness of the penalties has no real influence on the development of criminal tendencies; these must be regarded as the outcome of a man's development, and the important thing is to prevent the type of development which makes a man a criminal.

Scientific methods of controlling crime have an effect on social life in another respect—the prevention of unlawful acts. Criminal investigation laboratories are often asked to place their methods and experience at the service of organizations seeking to protect themselves against the risks of fraud. They are consulted in this way in the matter of identity cards, passports, banknotes, travelers' checks, and bonds. The better safeguarding of these documents makes their falsification more difficult and thus directly reduces incentive to crime. This is a new feature of the work of these laboratories, which will become steadily more important as scientific knowledge advances.

We have sought, in this paper, to show how scientific criminal investigation is revolutionizing the system of proof, which is the basis of all social law. One day, perhaps, scientific evidence of facts will almost entirely take the place of the unreliable evidence of men, so that justice will better fulfill its social function. That day, however, is still far off—for man's development, like that of things, is bound to be slow and gradual.

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The Great Piltdown Hoax[1]

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[With 2 plates]

When Drs. J. S. Weiner, K. P. Oakley, and W. E. Le Gros Clark [1] [2] recently announced that careful study had proved the famous Piltdown skull to be compounded of both recent and fossil bones, so that it is in part a deliberate fraud, one of the greatest of all anthropological controversies came to an end. Ever since its discovery, the skull of "Piltdown man"—termed by its enthusiastic supporters the "dawn man" and the "earliest Englishman"—has been a veritable bone of contention. To place this astounding and inexplicable hoax in its proper setting, some account of the facts surrounding the discovery of the skull and of the ensuing controversy seems in order.

Charles Dawson was a lawyer and an amateur antiquarian who lived in Lewes, Sussex. One day, in 1908, while walking along a farm road close to nearby Piltdown Common, he noticed that the road had been repaired with peculiar brown flints unusual to that region. These flints he subsequently learned had come from a gravel pit (that turned out to be of Pleistocene age) in a neighboring farm. Inquiring there for fossils, he enlisted the interest of the workmen, one of whom, some time later, handed Dawson a piece of an unusually thick human parietal bone. Continuing his search of the gravel pit, Dawson found, in the autumn of 1911, another and larger piece of the same skull, belonging to the frontal region. His discoveries aroused the interest of Sir Arthur Smith Woodward, the eminent paleontologist of the British Museum. Together, during the following spring (1912), the two men made a systematic search of the undisturbed gravel pit and the surrounding spoil heaps; their labors resulted in the discovery of additional pieces of bone, comprising—together with the fragments earlier recovered by Dawson—the larger

[1] Reprinted by permission from Science, vol. 119, No. 3087, Feb. 26, 1954.
[2] Numbers in brackets indicate references at end of text.

part of a remarkably thick human cranium or brain case and the right half of an apelike mandible or lower jaw with two molar teeth in situ [2]. Continued search of the gravel pit yielded, during the summer of 1913, two human nasal bones and fragments of a turbinate bone (found by Dawson), and an apelike canine tooth (found by the distinguished archeologist, Father Teilhard de Chardin) [3]. All these remains constitute the find that is known as Piltdown I.

Dawson died in 1916. Early in 1917, Smith Woodward announced the discovery of two pieces of a second human skull and a molar tooth [4]. These form the so-called Piltdown II skull. The cranial fragments are a piece of thick frontal bone representing an area absent in the first specimen and a part of a somewhat thinner occipital bone that duplicates an area recovered in the first find. According to Smith Woodward's account, these fragments were discovered by Dawson early in 1915 in a field about two miles from the site of the original discovery.

The first description of the Piltdown remains, by Smith Woodward at a meeting of the Geological Society of London on December 18, 1912 [2], evoked a controversy that is probably without equal in the history of paleontological science and which raged, without promise of a satisfactory solution, until the studies of Weiner, Oakley, and Clark abruptly ended it. With the announcement of the discovery, scientists rapidly divided themselves into two main camps representing two distinctly different points of view (with variations that need not be discussed here) [5].

Smith Woodward regarded the cranium and jaw as belonging to one and the same individual, for which he created a new genus, *Eoanthropus*. In this monistic view toward the fragments he found ready and strong support. In addition to the close association within the same gravel pit of cranial fragments and jaw, there was advanced in support of this interpretation the evidence of the molar teeth in the jaw (which were flatly worn down in a manner said to be quite peculiar to man and quite unlike the type of wear ever found in apes) and, later, above all, the evidence of a second, similar individual in the second set of skull fragments and molar tooth (the latter similar to those imbedded in the jaw and worn away in the same un-apelike manner). A few individuals (Dixon [6], Kleinschmidt [7], Weinert [8]), moreover, have even thought that proper reconstruction of the jaw would reveal it to be essentially human, rather than simian. Reconstructions of the skull by adherents to the monistic view produced a brain case of relatively small cranial capacity, and certain workers even fancied that they had found evidences of primitive features in the brain from examination of the reconstructed endocranial cast [9, 10]—a notoriously unreliable procedure; but subsequent altera-

tions of reconstruction raised the capacity upward to about 1,400 cc.—close to the approximate average for living men [10, p. 596].

A number of scientists, however, refused to accept the cranium and jaw as belonging to one and the same kind of individual. Instead, they regarded the brain case as that of a fossil but modern type of man and the jaw (and canine tooth) as that of a fossil anthropoid ape which had come by chance to be associated in the same deposit. The supporters of the monistic view, however, stressed the improbability of the presence of a hitherto unknown ape in England during the Pleistocene epoch, particularly since no remains of fossil apes had been found in Europe later than the Lower Pliocene. An anatomist, David Waterston, seems to have been the first to have recognized the extreme morphological incongruity between the cranium and the jaw. From the announcement of the discovery he voiced his disbelief in their anatomical association [11, p. 150]. The following year (1913) he demonstrated that superimposed tracings taken from radiograms of the Piltdown mandible and the mandible of a chimpanzee were "practically identical"; at the same time he noted that the Piltdown molar teeth not only "approach the ape form, but in several respects are identical with them." He concluded that since "the cranial fragments of the Piltdown skull, on the other hand, are in practically all their details essentially human . . . it seems to me to be as inconsequent to refer the mandible and the cranium to the same individual as it would be to articulate a chimpanzee foot with the bones of an essentially human thigh and leg" [12].

In 1915, Gerrit Miller, then curator of mammals at the United States National Museum, published the results of a more extensive and detailed study of casts of the Piltdown specimens in which he concluded that the jaw is actually that of a fossil chimpanzee [13]. This view gradually gained strong support, e. g., from Boule [14] and Ramström [15]. Miller, furthermore, denied that the manner of wear of the molar teeth was necessarily a peculiarly human one; he stated that it could be duplicated among chimpanzees. That some other workers (Friederichs [16]; Weidenreich [17]) have ascribed the jaw to a fossil ape resembling the orangutan, rather than to a chimpanzee, is unimportant. What is important, in the light of recent events, is that the proponents of the dualistic theory agreed in pronouncing the jaw that of an anthropoid ape, and unrelated to the cranial fragments. Piltdown II remained a problem; but there was some ambiguity about this discovery, which was announced after the death of Dawson "unaccompanied by any direct word from him" [5]. Indeed, Hrdlička [18], who studied the original specimens, felt convinced that the isolated molar tooth of Piltdown II must have come from the original jaw and that there was probably some mistake in its published history.

A third and in a sense neutral point of view held that the whole business was so ambiguous that the Piltdown discovery had best be put on the shelf, so to speak, until further evidence, through new discoveries, might become available. I have not attempted anything resembling a thorough poll of the literature, but I have the distinct impression that this point of view has become increasingly common in recent years, as will be further discussed. Certainly, those best qualified to have an opinion, especially those possessing a sound knowledge of human and primate anatomy, have held largely—with a few notable exceptions—either to a dualistic or to a neutral interpretation of the remains, and hence have rejected the monistic interpretation that led to the reconstruction of a "dawn man." Most assuredly, and contrary to the impression that has been generally spread by the popular press when reporting the hoax, "Eoanthropus" has remained far short of being universally accepted into polite anthropological society.

An important part of the Piltdown controversy related to the geological age of the "Eoanthropus" fossils. As we shall see, it was this aspect of the controversy that eventually proved to be the undoing of the synthetic Sussex "dawn man." Associated with the primate remains were those of various other mammals, including mastodon, elephant, horse, rhinoceros, hippopotamus, deer, and beaver [2]. The Piltdown gravel, being stream-deposited material, could well contain fossils of different ages. The general opinion, however, seems to have been that it was of the Lower Pleistocene (some earlier opinions even allocated it to the Upper Pliocene), based on those of its fossils that could be definitely assigned such a date [2]. The age of the remains of "Piltdown man" thus was generally regarded as Lower Pleistocene, variously estimated to be from 200,000 to 1,000,000 years [19]. To the proponents of the monistic, "dawn-man" theory, this early dating sufficed to explain the apparent morphological incongruity between cranium and lower jaw.

In 1892, Carnot, a French mineralogist, reported that the amount of fluorine in fossil bones increases with their geological age—a report that seems to have received scant attention from paleontologists. Recently, K. P. Oakley, happening to come across Carnot's paper, recognized the possibilities of the fluorine test for establishing the relative ages of bones found within a single deposit. He realized, furthermore, that herein might lie the solution of the vexed Piltdown problem. Consequently, together with C. R. Hoskins, he applied the fluorine test to the "Eoanthropus" and other mammalian remains found at Piltdown [20]. The results led to the conclusion that "all the remains of *Eoanthropus* . . . are contemporaneous"; and that they are, "at the earliest, Middle Pleistocene." However, they were strongly indi-



1. Reconstruction of the Piltdown skull and jaw, after Smith Woodward.



2. Top view of the specimen shown in figure 1.



Fragments of the Piltdown I skull, jaw, and canine tooth.

cated as being of late or Upper Pleistocene age, although "probably at least 50,000 years" old [19]. Their fluorine content was the same as that of the beaver remains but significantly less than that of the geologically older, early Pleistocene mammals of the Piltdown fauna. This seemed to increase the probability that cranium and jaw belonged to one individual. But at the same time, it raised the enigma of the existence in the late Pleistocene of a human-skulled, large-brained individual possessed of apelike jaws and teeth—which would leave "Eoanthropus" an anomaly among Upper Pleistocene men. To complete the dilemma, if cranium and jaw were attributed to two different animals—one a man, the other an ape—the presence of an anthropoid ape in England near the end of the Pleistocene appeared equally incredible. Thus the abolition of a Lower Pleistocene dating did not solve the Piltdown problem. It merely produced a new problem that was even more disturbing.

As the solution of this dilemma, Dr. J. S. Weiner advanced the proposition to Drs. Oakley and Clark that the lower jaw and canine tooth are actually those of a modern anthropoid ape, deliberately altered so as to resemble fossil specimens. He demonstrated experimentally, moreover, that the teeth of a chimpanzee could be so altered by a combination of artificial abrasion and appropriate staining as to appear astonishingly similar to the molars and canine tooth ascribed to "Piltdown man." This led to a new study of all the "Eoanthropus" material that "demonstrated quite clearly that the mandible and canine are indeed deliberate fakes" [1]. It was discovered that the "wear" of the teeth, both molar and canine, had been produced by an artificial planing down, resulting in occlusal surfaces unlike those developed by normal wear. Examination under a microscope revealed fine scratches such as would be caused by an abrasive. X-ray examination of the canine showed that there was no deposit of secondary dentine, as would be expected if the abrasion had been due to natural attrition before the death of the individual.

An improved method of fluorine analysis, of greater accuracy when applied to small samples, had been developed since Oakley and Hoskins made their report in 1950. This was applied to the Piltdown specimens. The results of these new estimations, based mainly on larger samples, are given in the first and second columns of the accompanying table. Little elaboration is necessary. The results clearly indicate that whereas the Piltdown I cranium is probably Upper Pleistocene in age, as claimed by Oakley and Hoskins, the attributed mandible and canine tooth are "quite modern." As for Piltdown II, the frontal fragment appears to be Upper Pleistocene (it probably belonged originally to Piltdown I cranium), but the occipital frag-

ment and the isolated molar tooth are of recent or modern age. The foregoing conclusions are supported by evidence concerning the organic content of the specimens, as determined by analysis of their nitrogen content. This method is not as conclusive as fluorine analysis; but its results, given in the third column of the accompanying table, provide additional support for the conclusions arrived at by the fluorine-estimation method. In general, as would be expected, the nitrogen content decreases with age; the only specimen that falls out of line is the occipital of Piltdown II.

TABLE 1.—*Fluorine content, ratio of fluorine to phosphorus pentoxide, and nitrogen content of the bones and teeth of the so-called Piltdown I and Piltdown II skulls, compared with those of various Upper Pleistocene and Recent bones and teeth.* (From Weiner, Oakley, and Clark [1], rearranged.)

	% F	$\frac{\%\ F \times 100}{\%\ P_2O_5}$	%N
Upper Pleistocene:			
Bones (local) (minimum F content)	0. 1	0. 4	-----
Teeth, dentine (minimum F content)	0. 1	0. 4	-----
Bone (London)	------	----------	0. 7
Equine molar, dentine (Piltdown)	------	----------	1. 2
Human molar, dentine (Surrey)	------	----------	0. 3
Recent:			
Neolithic bone (Kent)	------	----------	1. 9
Fresh bone	------	----------	4. 1
Chimpanzee molar, dentine	<0. 06	<0. 3	3. 2
Piltdown I:			
Cranium	0. 1	0. 8	1. 4
Mandible, bone	<0. 03	<0. 2	3. 9
Mandibular molar, dentine	<0. 04	<0. 2	4. 3
Canine	<0. 03	<0. 2	5. 1
Piltdown II:			
Frontal bone	0. 1	0. 8	1. 1
Occipital bone	0. 03	0. 2	0. 6
Isolated molar, dentine	<0. 01	<0. 1	4. 2

Weiner, Oakley, and Clark also discovered that the mandible and canine tooth of Piltdown I and the occipital bone and molar tooth of Piltdown II had been artificially stained to match the naturally colored Piltdown I cranium and Piltdown II frontal. Whereas these latter cranial bones are all deeply stained, the dark color of the faked pieces is quite superficial. The artificial color is due to chromate and iron. This aspect of the hoax is complicated by the fact that, as recorded by Smith Woodward [21], "the colour of the pieces which were first discovered was altered a little by Mr. Dawson when he dipped them in a solution of bichromate of potash in the mistaken idea that this would harden them." The details of the staining, which confirm the conclusions arrived at by microscopy, fluorine analysis, and nitrogen estimation, need not be entered into here.

In conclusion, therefore, the *disjecta membra* of the Piltdown "dawn man" may now be allocated as follows: (1) the Piltdown I cranial fragments (to which should probably be added Piltdown II frontal) represent a modern type of human brain case that is in no way remarkable save for its unusual thickness and which is, at most, late Pleistocene in age; (2) Piltdown I mandible and canine tooth and Piltdown II molar tooth are those of a modern anthropoid ape (either a chimpanzee or an orangutan) that have been artificially altered in structure and artificially colored so as to resemble the naturally colored cranial pieces—moreover, it is almost certain that the isolated molar of Piltdown II comes from the original mandible, thus confirming Hrdlička's [18] earlier suspicion; and (3) Piltdown II occipital is of recent human origin, with similar counterfeit coloration.

Weiner, Oakley, and Clark conclude that "the distinguished palaeontologists and archaeologists who took part in the excavations at Piltdown were the victims of a most elaborate and carefully prepared hoax" that was "so extraordinarily skilful" and which "appears to have been so entirely unscrupulous and inexplicable, as to find no parallel in the history of palaeontological discovery."

It may be wondered why 40 years elapsed before the hoax was discovered. Two factors enter here: first, there was no reason at all to suspect the perpetration of a fraud, at least, not until fluorine analysis indicated the relative recency of all the specimens, thus making the association of a human cranium and an anthropoid-ape jaw, either anatomically or geologically, hardly credible; and, second, methods for *conclusively* determining whether the specimens were actual fossils or faked ones, short of their wholesale destruction, were developed only in recent years (it will be recalled that even the fluorine-estimation method used by Oakley and Hoskins a few years ago was inadequate for detecting a significant difference between brain case and jaw). It is of interest to note that Dawson, in his original report [2], stated:

> A small fragment of the skull has been weighed and tested by Mr. S. A. Woodhead, M.Sc., F.I.C., Public Analyst for East Sussex & Hove, and Agricultural Analyst for East Sussex. He reports that the specific gravity of the bone (powdered) is 2.115 (water at 5° C. as standard). No gelatine or organic matter is present. There is a large proportion of phosphates (originally present in the bone) and a considerable proportion of iron. Silica is absent.

This statement obviously refers to the brain case alone; for, in both the title and text of the original report the authors spoke of "skull *and* mandible" (italics mine). One cannot help but wonder what might have come to pass if samples of the jaw and teeth had also been submitted to chemical analysis, even though the present, more refined methods were not then available.

The ready initial acceptance of the Piltdown discovery at its face value, at least by a majority of interested scientists, can probably be attributed to the philosophical climate that invested the problem of human evolution at that time. In September 1912, before the announcement of the discovery of "Piltdown man," the distinguished anatomist Elliot Smith, in an address before the Anthropological Section of the British Association for the Advancement of Science at Dundee [22], expressed a prevailing point of view when he developed the theory that the brain led the way in the evolution of man and that modification of other parts of the body followed. Thus the stage was set for the ready acceptance of the Piltdown fragments as constituting a single individual, a "dawn man" possessing a human cranium housing a human brain, but with phylogenetically laggard, hence simian, jaws and teeth. To quote the paleontologist Sollas [23]:

> The surprise which was first excited by what appeared to be a monstrous combination disappears on further reflection. Such a combination had, indeed, been long previously anticipated as an almost necessary stage in the course of human development. . . . In *Eoanthropus Dawsoni* we seem to have realised precisely such a being . . . , one, that is, which had already attained to human intelligence but had not yet wholly lost its ancestral jaws and fighting teeth.

And, as Sir Arthur Keith, perhaps the most vocal champion of "Eoanthropus," argued in supporting this view:

> . . . before the anthropoid characters would disappear from the body of primal man, the brain, the master organ of the human body, must first have come into its human estate. Under its dominion the parts of the body such as the mouth and hands, the particular servants of the brain, became adapted for higher uses. Looking at the problem from this point of view, we cannot reject the Piltdown mandible because as regards the mylo-hyoid ridge it is simian and not human in character [10].

Recent finds of fossil men and other primates, however, indicate that it is the brain that was the evolutionary laggard in man's phylogeny; indeed, the studies of Tilly Edinger [24] of the phylogeny of the horse brain suggest that this may well be a general rule in mammalian evolution. It was such concepts as this, leading to a change in philosophical climate, that evoked an increasing skepticism toward the validity of the monistic interpretation of the Piltdown fragments and led in turn to what appears to have been the prevailing recent opinion, namely, that the fragments should, as expressed in 1949 by Le Gros Clark [25], "be laid aside without further comment until more evidence becomes available." This view, enhanced by the redating of the remains by Oakley and Hoskins, provided the proper psychological setting for the coup de grâce delivered by Weiner, Oakley, and Clark.

As the three latter point out, the solution of the Piltdown enigma greatly clarifies the problem of human evolution. For "Eoanthropus," both morphologically and geologically, just simply did not fit into

the picture of human evolution that has gradually been unfolding as the result of paleontological discoveries throughout the world.

The Piltdown story is a significant one in the history of ideas, more particularly as it bears on the concept of the precise course of human evolution. For, if man's biological history be likened to a book, it is seen to be composed of both blank and written pages and, by those who note them carefully, many if not most of the written ones will be seen to be in the nature of palimpsests—pages that have been rewritten after their original writing has been rubbed out. Of this, the Piltdown affair is a striking demonstration. It is a demonstration, furthermore, that the palimpsest nature of the pages of man's history is not always due directly to new fossil discoveries but can also result from changes in the philosophical climate of the science. That this phenomenon is peculiar to anthropology, however, is seriously to be doubted.

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Our State Names

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Over the years, correspondence of the Bureau of American Ethnology has shown that there is much popular interest in the origin and meaning of the names of the States and Territories that comprise our republic. In compiling answers on this subject I was forced to look minutely into several of these names, and as a result finally decided to extend the study to all. I soon discovered that the task would have been simpler had it been undertaken 100 years ago. Twenty-six out of the total of 51 names turned out to be of American Indian origin, and one of Polynesian. Half of the names are, therefore, from indigenous languages. Of the 6 New England States only 2—Massachusetts and Connecticut—have names of Indian origin.

Our State names are almost entirely a product of chance. A haphazard aggregation has grown into official usage, as irregularly as the typical American city grows into shape. There were, of course, no analogous political regions in aboriginal times, so names became adopted in various ways. Often the earliest use of a name that later came into prominence received little attention as regards recording. There are seven State names of Indian origin that constitute what I call the early cycle. These are Connecticut, Kentucky, Massachusetts, Ohio, Tennessee, Wisconsin, and Wyoming. Most of them have been difficult to trace.

Each State, district, or Territory name has had a long usage and has considerable history behind it. Of the so-called original Thirteen Colonies of the Atlantic seaboard, each had a name already firmly established before the time of the Revolutionary War. The later States, however, regularly went through two stages, being at first Territories and then States, the Territory name usually becoming the State name.

Several of the names are modified by such terms as "North," "South," "West," and "New." The most employed of these modificatory words is "New," appearing in the names New Hampshire, New Jersey, New Mexico, and New York. In many instances an Old World

place name has been transferred to the New World. The two names Carolina and Dakota put in their appearance as State names modified oppositionally into pairs by the preplacing of North or South. West Virginia alone has the preplacing of West, and the name of the old original Virginia is not modified to balance this. The two State names Arkansas and Kansas are of the same origin, derived through different channels.

The various State names can be segregated into several sections according to reference.

ORIGINS

Tribal Names.—Of the many American Indian tribe names formerly occurring in the region now comprised by the United States, only 12 have survived as State names: Alabama, Arkansas, Idaho, Illinois, Indiana, Iowa, Kansas, Missouri, North Dakota, Oklahoma, South Dakota, Utah. Although fundamentally the names of tribes, they were also employed in native and other languages as designations of habitat, but in English, usually of rivers.

Place Names.—Seventeen of our State names are of place-name origin, having received their present application usually *per extensionem:* Alaska, Arizona, California, Hawaii, Kentucky, Maine, Massachusetts, Michigan, Nevada, New Hampshire, New Jersey, New Mexico, New York, Rhode Island, Tennessee, Vermont, Wyoming.

Geographical Terms.—There are only two names of geographical-term origin: Montana and Pennsylvania. Montana is the Latin feminine singular of the adjective *montaanus*, "mountainous." Pennsylvania is a compound word. While honoring William Penn's father as its first syllable, -sylvania is a feature-denoting word in neo-Latin, signifying woodland and having somewhat more definite meaning than the throwing of a Latin adjective into the feminine singular.

River Names.—State names of purely river-name origin number nine: Colorado, Connecticut, Minnesota, Mississippi, Nebraska, Ohio, Oregon, Wisconsin.

Greeting Terms.—The only name in this category is Texas.

Name Referring to a Male Person of Nobility or Rank.—The State names in this category number seven: Delaware, District of Columbia, Georgia, Louisiana, North Carolina, Pennsylvania, South Carolina, and Washington.

Names Referring to a Female Person of Nobility or Rank.—There are three State names of this class, referring to two queens of England: Maryland, Virginia, West Virginia.

Name Referring to Day of Discovery.—The name Florida, referring to Easter Sunday, was bestowed by Ponce de Leon because of his first sighting of the peninsula of Florida on Easter Sunday, 1512.

Nine of the State names are, or can be conceived of as being, Latin feminine singulars of adjectives, used as nouns: California, Georgia, Indiana, Louisiana, Montana, North Carolina, South Carolina, Virginia, West Virginia.

Two of the State names have been revamped with respect to meaning: Massachusetts, Michigan. All the State names have been revamped with respect to form.

Erroneous definitions of State names belong in the same class as nicknames, as they usually attribute falsely some flattering or beautiful meaning to a name which in reality has another origin. Thus when we assume that Idaho means "gem of the mountains," this erroneous interpretation is practically the same as a flattering nickname. North Carolina has long been referred to as the "land of the sky," which suggests also the frequent reference to Minnesota as the "land of the sky-blue water," partly as the result of the English wording of a popular song.

ANALYSIS

Alabama.—According to the researches of Dr. Mary R. Haas, the native form of the name in the Alabama Indian language (Muskhogean) is Alpaamó, plural Alpaamohá. It was originally the name of a place and tribal town, which was a member of the Creek confederacy. Earliest records show it on the Alabama River, just below the confluence of the Coosa and the Tallapoosa. The name is still applied to the tribe, and this application has preserved it from loss. Modern Indians can give no meaning to the name, and it may have been the designation of the place in some other language. At least this theory would explain the name's having no known meaning. In some dialects the name alpaamó appears with initial h: Halpaamó, and Cyrus W. Byington ("A Dictionary of the Choctaw Language," Bur. Amer. Ethnol. Bull. 46, 1946) gives the name with initial h, as does Spotswood, 1720 (North Carolina Colonial Records, II, p. 383, 1886), who writes "Habbamalas" (bb a mistake for lb). The Ross map of 1765 shows the name as "Alibamons." The i in the second syllable may have been an early pronunciation.

In 1817 Mississippi Territory was divided, the eastern half becoming Alabama Territory, which in 1819 was made a State. An erroneous belief of wide circulation is that Alabama means "here we rest."

Alaska.—The name in the Aleutian language of the Eskimoan stock (dialect of Unalaska) of the Alaska Peninsula, which is that part of the mainland of Alaska that juts out toward the eastern end of the Aleutian Island chain, is 'Aláxsxaq. The boundaries of the Alaska Peninsula are indefinite to the east and the Aleutian name has no transparent etymology. Aláxsxaq is a normal Aleut noun, and, according

to speakers of the Unalaska dialect of Aleutian, refers to a land, not to an island. The ordinary Russian corruption of this Aleutian noun was Alʸakša, but sometimes Alʸaška. The reference in Russian was to the Alaska Peninsula. The region that we call in English Alaska was always referred to by the Russians as Russian America. Alaska became a Territory of the United States as a result of the Alaska Purchase of 1867, and was designated as Alaska Territory, the name Alaska being extended to designate the entire mainland and islands of the purchase.

Arizona.—The originating form of the name Arizona is in the Papago dialect of the Pima language, of the Shoshonean stock, and is 'Arishóonak, meaning "little spring place." The springs referred to are in the bed of Arizona Creek 1 mile upstream from the Arizona ranchhouse, which is itself 1 mile up Arizona Creek from Planchas de Plata Creek, where a fabulous find of silver in its native state was made about 1735. The Spanish corruption of 'Arishóonak as Arizonac, also Arizona, and the word was taken over in the latter form by the Americans. The region of the springs is in the northern part of Sonora, Mexico, and not within the present bounds of the United States. The Arizona of the United States consists of land acquired through the Mexican cession of 1846 and the Gadsden Purchase of 1855. Arizona became a Territory in 1863 and a State in 1912. Among several other names proposed for application to the new Territory, Arizona happened to be adopted.

Arkansas.—The State name Arkansas is another form of the State name Kansas. Both orthographies are French in origin, the final s of both names being silent in French. The State of Arkansas was part of the land acquired by the Louisiana Purchase. The Marquette map of 1673 is the first recording of this name. Arkansas Territory was created in 1819 and became a State in 1836. See "Kansas" for etymology.

California.—The name California is the old Spanish designation of the peninsula of Lower California. This name was at its very inception applied both to the pearl-fishing colony of Cortés, established May 3, 1535, and to its hinterland. This colony was apparently on Santo Espíritu Island in La Paz Bay, situated in the southern part of the eastern coast of the peninsula. Perhaps Cortés and others started calling the place California, but why was not known.

In 1862 Hale called the attention of historians and of the world to the fact that California is the name of the Amazon island in Montalvo's sixteenth-century Spanish novel called "Esplandián." The New World place name must have been taken from the name in the novel, but no historical statement to this effect has ever been discovered. Subsequent to this discovery by Hale, earlier etymologies of the word California have retreated.

What the source of Montalvo's name California may have been remains a matter of conjecture. Did he make the word up out of whole cloth, or did he follow some traditional word that came down from the Middle Ages? The Roland poem, which dates perhaps from 1150, has at the end of its line 2948 the strikingly similar form "califerne" as the name of a region, perhaps situated near Africa; and the Antioch poem, which is still earlier, dating perhaps from 1110, has "(h)oliferne" as the name of the sultancy of Aleppo and Mosul, just beyond the Crusader kingdom of Antioch. May one of these earlier forms have reached Montalvo in some way?

Connecticut.—According to historical information and the linguistic studies of Siebert, the colony and later State name Connecticut was taken into English from the name of the Connecticut River, the originating form having been in Mahican and other similar Algonquian dialects of southwestern New England, KwEnihtEkot, or some form very similar to this, signifying "long river place." The Connecticut River, one of the long rivers that flow south to the southern New England shore, evidently had this name in local and more remote Indian dialects. The name Connecticut was applied to the river as far north as Springfield, Mass. The etymology of Connecticut as meaning "long river" was already on record in 1631. The ct in the English version of the name is produced by analogy with the English word "connect."

Trumbull in his Natick dictionary translates the word as "a wave or rough watered river," while Heckewelder in his "Historical Account" says that its Delaware cognate means "a rapid stream."

Colorado.—The Latin adjective *colooraatus*, means red or brown. From it comes Spanish "colorado," the usual Spanish adjective meaning red. Colorado as applied to the Colorado River is a descriptive term, referring to the red color of the water. Indians speaking many languages, living more or less in the vicinity of the Colorado River, tended to use this description of the river in addition, perhaps, to other methods of reference. The area of Colorado State is derived from three sources: the Louisiana Purchase, Texas, and the Mexican cession. Colorado Territory was created in 1846, Colorado State in 1876. The name Colorado was adopted because the Colorado River had its headwaters in the western half of Colorado Territory. The principal affluent of the Colorado River in Colorado was called Grand River, with the result that for many years there was no stream called Colorado within the limits of the present State. The name of the Grand River was changed to the Colorado River by the Colorado State Legislature on March 24, 1921, and by act of Congress, approved July 25, 1921.

Delaware.—The name of the State of Delaware was taken from the river of that name, at the mouth of which the State of Delaware is

located. The Delaware River was named in honor of Sir Thomas West, first Governor of the Virginia Company, 1610, in the reign of James I, King of England. His title in the British peerage was Lord De La Warr, the barony De La Warr dating from the thirteenth century. The name De La Warr is spelled a number of different ways but the State name is one word. The Delaware Indians also get their name from their former habitat along the Delaware River.

District of Columbia.—The District of Columbia, seat of the Federal Government and the capital of the United States, created January 24, 1791, was carved out of the States of Maryland and Virginia at the close of the Revolutionary War. The form "Columbia" is the feminine, used as a country name, of an assumed neo-Latin adjective *columbius*, "pertaining to Columbus."

Florida.—Ponce de Leon was apparently the first white man to sight the coast of Florida and he named it in honor of Easter Sunday, the day in 1512 on which this land was discovered. Easter is called in Spanish the Pascua Florida, literally the "floral Passover." It was the custom of the Spaniards to name a country for the day on which it was discovered. The Spanish name Florida, accented on the next to last syllable, is usually misaccented on the first syllable in English. Florida was acquired from Spain by conquest and cash settlement in 1819 and became a State in 1845.

Georgia.—Georgia was named in honor of George I and George II, kings of England. George I made a grant to Montgomery about 1717, but this grant expired in 3 years. In 1732, Oglethorpe obtained a charter and named the land Georgia in honor of George II, then king. Georgia is the neo-Latin feminine country-name counterpart of the name George, borne by several British kings and preeminently by St. George, patron saint of England. George, according to etymology, signifies "farmer," literally "earth worker," being a compound word in ancient Greek denoting "earth-worker."

Hawaii.—Hawaii, the name of the largest and most southeasterly of the Hawaiian group of islands, is in local linguistic form, Haway'i. Beyond this information one cannot go with certainty. It appears that perhaps an early form of the word was Kaway'i and that the meaning was "homeland."

A Spaniard named Juan Gaetano discovered the Hawaiian Islands in 1555. Hawaii was created a Territory in 1898.

Idaho.—Idaho was the old name of the Salmon River tribe of Indians of Shoshonean stock. This tribe was called the salmon tribe, in accordance with the occurrence of salmon, even as the whites say Salmon River today. Ida- means "salmon," and -ho means "tribe," literally "eaters," hence "salmon eaters." Idaho Territory was created by Congress in 1863, the name Montana Territory having first been proposed. Idaho State was created in 1890.

Joaquin Miller, the poet, erroneously guessed Idaho to mean "sun-up" in Shoshoni. Another erroneous interpretation of the name that has gained wide circulation is "gem of the mountains."

Illinois.—The Illinois River runs southwest across most of the State of Illinois and empties into the Mississippi River not far north of where the Missouri River joins the Mississippi. The Illinois tribe of Indians, speaking a language of the Algonquian stock very closely related to the Peoria language, inhabited the lower course of the Illinois River. The Illinois name of the Illinois tribe, also in use in Peoria, is 'ilini (plural 'iliniwak). The earliest published occurrence of this name is on the Marquette map, 1673, which labels Lake Michigan "Lac des Ilinois." La Salle traveled up the Illinois River in 1679 and named it from the tribe of Indians that he found inhabiting its banks. In the Illinois and Peoria languages 'ilini means (1) "man," "a warrior"; (2) a person of the Illinois tribe of Indians, no matter of what age or sex. French Ilinois (Marquette uses only one l), used both as the singular and the plural in French, is based on the Illinois plural 'iliniwak, eliminating the third syllable of the Illinois plural and substituting for -wak, of the Illinois plural, the Franch -ois, pronounced in standard Modern French as -wa (with silent s). Illinois Territory was created 1809, Illinois State 1818.

Indiana.—Indiana is the feminine of a Latin adjective *Indiaanus*, the feminine being used as a country-name noun, the appropriateness of the name being that certain Indian tribes were early settlers in Indiana. There exists such an adjective as *indiaanus* in Latin, but the common Latin adjective is *indicus*, Indian. Indiana Territory was created in 1800, Indiana State in 1816.

Iowa.—Iowa is in origin a tribe name, the Iowa tribe having spoken a Siouan language closely related to the Oto and Missouri languages. The name of the Iowa tribe was applied to the Iowa River, which is the principal stream of southeastern Iowa and runs southeast into the Mississippi. Through the application to the river, the name was adopted for the Territory and State. The Iowa form of the tribal name is 'Ayuxwa, which means "one who puts to sleep." Perhaps the Iowa Indians were so called because they had the power to put a visitor to sleep, or there was perhaps in very early times some connection in fact or story, now forgotten. This has frequently been erroneously translated "the sleepy ones." The early French spelled the tribal name usually Ayoua, the English Ioway. Iowa was made a Territory in 1838, a State in 1846.

Kansas.—Kansas is the name of a tribe of the Siouan stock, speaking a language closely related to that of the Kaw and Omaha. The Kansas, Kaw, and Omaha form is the same, according to Dr. Francis La Flesche, formerly ethnologist of the Bureau of American Ethnology, and is KáNze, with the accent on the first syllable. The Osage

and the Dakota Sioux name is also exactly the same. Kansas is a French spelling, the final s being silent in French pronunciation, as it still is in the Federally approved pronunciation of Arkansas. The name KaNze, in the Kansas language at least, means "the south-wind." The Kansas River is a large river of northeast Kansas and the name of the tribe being applied to the river, the application to the Territory and State was natural. The Kansas region was within the Louisiana Purchase except for the southwest corner, which was taken from Texas. Kansas Territory was created in 1854, Kansas State in 1861.

Kentucky.—The earliest occurrence of the word Kentucky is from the pen of Major Trent, in 1753, and the spelling is exactly the same as today. From 1794 comes the recording of the name which is next oldest, Cane-tuck-ee. The name is merely the Wyandot Iroquoian word for plain, and was applied originally to Kentucky Plains in what is now Clark County, central Kentucky. Kentucky was long a vague "province" of Virginia. A common erroneous belief is that Kentucky signifies "dark and bloody ground." In 1790 Kentucky was made a Territory, and in 1792 a State.

Louisiana.—Louisiana is the feminine of a Latinlike adjective, used as a country name. It was first applied by La Salle in 1682 in honor of Louis XIV of France to the entire Mississippi Valley and region of the later Louisiana Purchase. The State of Louisiana is only a small part of the vast area originally bearing this appellation. The French spelling is La Louisianne, always with the definite article. The territory of Orleans was created out of part of the Louisiana Purchase in 1804 and Louisiana State was created out of Orleans Territory in 1812.

Maine.—Maine was the name of a former province of France, very prominent in earlier times, and is guessed to be derived from the last two syllables of Ceno-manni, a Celtic tribe mentioned by Caesar, located where Maine is now. In America the early French gave the names Maine and Arcadie. The southern part of Maine was one of the Thirteen Colonies; the northern part was fixed by treaty between the United States and Great Britain in 1842. The French pronunciation is Meen, with long open ee. Other sources state that Maine originally signified the mainland country.

Maryland.—Maryland was named in honor of Queen Henrietta Maria, wife of Charles I of England. Henrietta Maria was the daughter of Henry IV, King of France. Charles I proposed that the colony of Maryland be called for his wife Mary, Maryland, Latin *Terra Mariae*, and this designation of the colony was written into the charter given by Charles I to the first Lord Baltimore. Henrietta Maria was called Mary by many of the writers of the time. A popular fancy is that the State of Maryland was named after the Virgin Mary, since it was a Catholic colony.

Massachusetts.—The Massachusetts tribe of Indians, which dominated the region of Massachusetts Bay in pre-Columbian times, belonged to the Algonquian stock and spoke a northern dialect of Narraganset. According to the map of Capt. John Smith, the Massachusetts Indians were named from Great Blue Hill, 2 miles south of Milton, Mass., on the top of which there is now an observatory. The hill can be seen from Boston Harbor. The originating form was perhaps mes-atšu-s-et, "large hill place."

We are now able to explain why Josiah Cotton, who took down a Massachusetts vocabulary in 1702, states in that vocabulary that Massachusetts means arrowhead hill. The Massachusetts term for flint sounded similar to the term for large. Massachusetts Hill is a hillock near the mouth of Sachem's Creek in Quincy, Mass. Since this hillock is not large, its name may easily contain the term for flint. But the name of the tribe was taken from Great Blue Hill.

The colony and later State of Massachusetts received its name by the extension of this term.

Michigan.—The name Michigan first appears in the writings of Alouet, 1672, and evidently applied to a large clearing on the west side of what is now known as Michigan lower peninsula. Frederic Baraga ("A Dictionary of the Otchipwe (Chippewa) Language," Cincinnati, 1853) gives "Clearing, majiigan." Michigan was later erroneously thought to go back to Chippewa micigami, which is one way of saying "large water," although a more natural way of talking in Chippewa would be to say kitcigami or kitcizagiigan, -zagiigan meaning "lake." Evidently the name Michigan originally referred to the clearing, and later the French and English-speaking whites extended it to refer to Lake Michigan. Michigan was made a Territory in 1805, a State in 1837.

Minnesota.—The prominent river in what is now the southern part of the State of Minnesota, a western affluent of the Mississippi River, is now called the Minnesota River, but was earlier called St. Peter's River (French, rivière de Saint Pierre). Stephen Return Riggs ("A Dakota-English Dictionary," Contributions to North American Ethnology, vol. 7, 1890) shows that the name Minnesota in the originating Dakota Sioux form Mnishota, signifies "milky" or "clouded water." There are two other possible derivations, mnihhota, "gray water," and mnisota, "used up or dwindled water." The old Indians of Riggs' time believed that mnishota was the original form. The name of the river was later extended to the Territory and State.

Jonathan Carver's "Travels through the Interior Parts of North America" (London, 1778) contains the earliest occurrence of the word Minnesota, spelled Menesoter. Gen. Sibley, who took an active part in the creation of Minnesota Territory in 1849, is responsible for the spelling Minnesota. Minnesota State was created in 1858.

Mississippi.—The earliest occurrence of the name Mississippi is on the La Salle map of 1695, La Salle having been the first to navigate down the Mississippi River, in 1682. The name is patently from some language or dialect of the Algonquian stock, probably Chippewa, the meaning being "large river." The designation is descriptive, but was probably used in Pre-Columbian times, for one way of saying "large river" in Chippewa is Mici-zibi (mici-, "large"; zibi, "river"), and the French orthography cited above is intended for this form, for even Ottawa, another language of the Algonquian stock, has meci- instead of mici-, and the French form probably comes from a tongue which has mici-. The name of the Mississippi River has been erroneously stated to mean "large water," and "father of waters."

In 1798, previous to the Louisiana Purchase, Mississippi Territory was created by Congress out of what was then part of Florida, the Mississippi River name being bestowed on the Territory. In 1817, with the division of Mississippi Territory, the eastern half became Alabama Territory, and Mississippi became a State.

Missouri.—The Marquette map, 1673, has on it the earliest occurrence of the word Missouri in the form 8emess8rit. (Marquette uses 8 instead of French ou.) The modern form lacks both the beginning and end. Although the French orthography has double s, showing that the sound is to be pronounced sharp, the current English pronunciation is to sound the ss as z. The name signifies "canoe haver." The canoes referred to were dugouts.

The Missouri were a small tribe perhaps belonging to the Algonquian stock and living on the Missouri River, their neighbors to the west being the Little Osage and to the east the Illinois. According to information supplied by Swanton, the Missouri had a tradition that their ancestors came from the Illinois River. Also, according to Swanton, the survivors of the Missouri tribe became mixed with Oto-speaking Indians, and the Missouri Indians still living speak only Oto.

The Missouri River got its name from the Missouri tribe, and when Missouri Territory was created in 1817 out of a portion of the Louisiana Purchase, the name of the Missouri River was applied to the Territory. The State of Missouri was created in 1821. The name Missouri is sometimes erroneously said to mean "muddy water" or "big muddy."

Montana.—Montana is the only State that has a classical Latin name. Several others have neo-Latin names, but the word "montana" is standard Latin. It is the feminine of the adjective *montaanus*, "mountainous," "having mountains," and is properly used only as a country-name noun. There is no indication in connection with the application of the name that it is Latin neuter plural, which would

have the same form, or that the name is Spanish "montaña," an unusual Spanish word for mountain.

In 1863 it was proposed that the Territory then created be called Montana Territory, but the name Idaho Territory was adopted instead. Montana Territory was created in 1864, the name unsuccessfully proposed the year previous becoming adopted. In 1889 Montana became a State.

Nebraska.—The principal river is the Platte, called in French la rivière Platte, meaning "the broad river." According to Dr. La Flesch, a native Omaha who also spoke French, the State of Nebraska derives its name from the Omaha name of the Platte River, which is Nibôápka (ni, "water"; bôápka, "broad"), the meaning being the same as that of la rivière Platte. Fremont, who went to what is now Nebraska in 1842, was the first to use the name Nebraska, applying it to the Platte River. According to La Flesche, Nibraska would be a more correct pronunciation. Nebraska Territory was created in 1854, Nebraska State in 1864.

Nevada.—Nevada is an abbreviation for Sierra Nevada, Spanish for "snowy range." Spanish ships engaged in the trade between the Philippine Islands and Mexico used to sight these mountains when far off the California coast, in the 17th and 18th centuries, and spoke of them as la Sierra Nevada. Most of the Sierra Nevada range is in California. In February 1858, it was decided to form a new Territory out of western Utah and it was suggested that it be named after the Sierra Nevada. May 12, 1859, the Territory was admitted under the name of Nevada. Nevada became a State in 1864.

New Hampshire.—Hampshire is a famous shire or county of central England, the name of which was transferred to the New World colony. The county seat of Hampshire, England, is Hampton. The form of Hampton is in Anglo-Saxon Haamtuun, meaning "village." One early recording of Hampshire shows that it is short for Hamptonshire, in Anglo-Saxon Haamtuunsciir. In 1629 Mason gave the name New Hampshire to a part of the area comprised later by the State of New Hampshire.

New Jersey.—In the name Jersey, the initial J is for ch. Jersey is the principal one of the Channel Islands, and bore in Latin the name *Insula Caesareea*, literally "the Cesarian Island," meaning the Federal Island. *Caesareeus* is an adjective derived from Caesar, which name can perhaps be connected with the fifth declension noun of Latin, *caesariees*, "hairiness." In 1664 Lord Berkeley and Sir George Carteret, who was a native of the island of Jersey, named New Jersey when they were granted the charter for that colony.

New Mexico.—The Spanish form of this name, "Nuevo Mexico," was for several centuries used as a designation for the region of the upper

Rio Grande. When this region was annexed to the United States through the cession of 1846, the name was retained but with the translation into English as New Mexico. Mexico, in the official orthography of Mexico, is written Méjico, but the older orthography, Mexico, still largely obtains throughout the world, even in Spanish-speaking countries. The Aztec spelling is Mexìco, of which the pronunciation is mecí'ko, this being one of the names of Mexico City and apparently meaning the "place of Mexìtli." Mexìtli is a byname of Huitzilopochtli, the god whose temple stood where the cathedral now stands in Mexico City. The name Mexico also had, and still has, reference to the region of Mexico City and to the entire nation. New Mexico was created a Territory in 1850, a State in 1912.

New York.—The earlier name of New York was New Amsterdam, the capital of the Dutch colony of America, known as New Netherland. When Governor Stuyvesant, the last Dutch Governor of the Dutch colony, surrendered to the English in 1664, the Dutch colony came under the British crown. It was proclaimed at once that the name New Amsterdam be changed to New York, in honor of James, Duke of York and Albany, younger brother of Charles II of England. York is probably the corruption of a British word meaning "a grove of yew trees."

North Carolina.—The name Carolina is the feminine of a neo-Latin adjective *Caroliinus*, derived from neo-Latin *Carolus*, Charles. The name Carolina was first given in honor of Charles IX of France, but later grants were named in honor of Charles I and again of Charles II of England. The grant of Carolina of Charles I was made in 1629, of Charles II in 1663. North and South Carolina were made separate colonies in 1729.

North Dakota.—Dakota is the Dakota Sioux Indian word meaning "friend," in some of the eastern dialects beginning with l instead of with d. The k is aspirated and the accent is on the next to the last syllable. The originating form is dakhóta. Dakota Territory was created in 1861. The Territory received its name because of being occupied by the Dakota tribe. In 1889 North Dakota and South Dakota were admitted as separate States.

Ohio.— La Salle was the first European to discover the Ohio River, and wrote in 1680 that the Iroquois call it Ohio, spelling the name as it is spelled today, in French pronunciation, of course, the i being pronounced like English ee. W. N. Fenton states that what is evidently the same word is still in use in the Seneca language of the Iroquoian stock in the form 'Ohiiyo', the Seneca name of the Allegheny River. The ordinary word for "beautiful," "magnificent," in Seneca is wiiyo', which is to be connected, perhaps, with 'Ohiiyo'. The name 'Ohiiyo' is also applied by the Seneca to the Ohio River, into which the Allegheny River flows, and one of the informants stated that the name

means any large river. Ohio Territory was created in 1783, taking its name from the Ohio River. Ohio State was created in 1803.

Oklahoma.—The name Oklahoma is a coined word in Choctaw meaning "red person" ('ukla, "person"; humá', "red") and first appears in the Choctaw-Chickasaw Treaty of 1866. It was proposed by Rev. Allen Wright, a Choctaw-speaking Indian, who was a missionary. "Red person" or "red man" implies contrast with the Whites and was therefore not used in Pre-Columbian times to designate the Indians. Oklahoma Territory was created in 1890, Oklahoma State in 1907.

Oregon.—The name Oregon can be traced back to Rogers who in 1765 wrote Ourigan. There is strong evidence in records of the life of Rogers and that of his friend, Jonathan Carver, who also used the term, that the name Oregon is Canadian French in origin. The French word, standardly spelled ouragan, is used in Canadian French to mean any storm, although the word originally came into French from Spanish and is the same word as "hurricane," being ultimately of Carib Indian origin. The Columbia River, with special reference to its source, was probably referred to in very early times by some French-speaking trapper as la rivière des Ouragans, "the river of the squalls." Mackenzie, in a book published 1802, has a chapter entitled "The Hurricane" in which he describes a land storm, indicating that English usage sometimes agreed with that of the Canadian French. Bryant, in his poem entitled "Thanatopsis," first published in 1812, has Oregon as the name of the Columbia River. Other suggested meanings have been that Oregon is a corruption of the name Aragon, province of Spain, or that it stands for Spanish orejón, "big-ear," a name that has been applied to several Indian tribes. Capt. Bonneville, in a letter to Schoolcraft, stated that it was derived from the Spanish word for the *Artemesia* or wild sage, saying Spanish traders from Santa Fe called it Orégano and the old mountain men corrupted this to Oregon. There being plenty of sage in eastern Oregon, this was referred to as the Oregon or wild-sage country. Oregon Territory was created in 1848, bearing the old name of the Columbia River; Oregon State was established in 1859.

Pennsylvania.—Pennsylvania was named by Charles II, King of England, when he granted a charter to William Penn in 1680. It is a compound of *sylvania*, neo-Latin for woodland, with the prefix Penn, the surname of William Penn's father, Adm. William Penn. It had been the desire of William Penn, the son, to call the colony New Wales, but the King did not give this name.

Rhode Island.—The name originated with Adrian Block, who, writing in Dutch, called Rhode Island Roodt Eylandt, meaning "red island," "because of the fiery aspect of the place, caused by the red clay in some portions of its shores." The spelling Rhode in English is to

be expected, as it was in accordance with the standard way of spelling the syllable. An erroneous idea that it was named for the Island of Rhodes goes back at least as far as Roger Williams, who suggested it.

South Carolina.—See North Carolina.

South Dakota.—See North Dakota.

Tennessee.—The originating form is Tanasi, the Cherokee name of two different Cherokee villages on the Little Tennessee River, in what is now the southeast corner of the State of Tennessee. The etymology of the name is unknown. The Little Tennessee River was evidently called Tennessee from the name of these villages, and the name of the river was applied by extension to the State. The area of Tennessee was long considered to be a province of western Carolina. Tennessee became a State in 1796.

Texas.—The word "teysha" in the Caddo language is a salutation which is best translated as "hello friend." The word was widely used in Louisiana, Oklahoma, and Texas. In early literature it appears in the forms texas, texias, tejas, tejias, teysas, techan, etc., and was applied to various tribes, indicating that they were friendly. In Mexican Spanish the letter x had the sound of sh. The Spanish spelling was Anglicized to its present sound. The Spanish early applied the name to the tribes of the Caddo confederacy which later became Louisiana and eastern Texas, so that one spoke in Spanish of these tribes collectively as el reino de los Texas, "the kingdom of the Texas," and the first mission established by the Spanish, which was founded May 25, 1690, a little northwest of the present town of Weches in eastern Texas, was named San Francisco de los Texas, "St. Francis of the Texas." As the land of the Texas, the name was applied to the Republic of Texas in 1836. Texas became a State in 1845.

Utah.—The originating form for Utah is White Mountain Apache Yuttahih, literally "one that is higher up," now applied by the White Mountain Apache to the Navajo. The Spanish and English speakers have interpreted this name as referring to the Utes, who are still higher up in the mountain country than are the Navajo. The Ute are of Shoshonean stock, the Navajo, of Athapascan. As the country of the Utes, the name was applied to the region. In 1849 Utah was organized as an independent unit, termed "the Provisional State of Deseret." Utah was created a Territory in 1851, a State in 1896.

Vermont.—Champlain, on his map of 1647, designates the Green Mountains, which are the most conspicuous landmark of what is now the State of Vermont, as "Verd Mont," this designation evidently meaning "green mountain," although the standard Modern French for green mountain is montagne verte. Champlain did not visit the Green Mountains, he only saw them from a distance. It should be noted that he used the singular, whereas both French and English naturally use the plural. Modern French, imitating Champlain's

form, would have the spelling Vert Mont, and the pronunciation would be vär mON. The form would be considered as correct, but not customary.

Virginia.—The English colony of Virginia was named in 1584 in honor of Elizabeth, Queen of England, who was widely termed the Virgin Queen. Virginia is the feminine of the neo-Latin adjective *virginius*, used as a country-name noun.

Washington.—In 1853, Washington Territory, created out of part of Oregon Territory, received the name of Washington in honor of George Washington. Washington State was created in 1889. The name Washington would be more correctly spelled Wassington. It derives from two words in Anglo-Saxon: "Wassinga Tuun," meaning the ville, city, or stockade of the Wassings.

West Virginia.—West Virginia was set aside from Virginia in 1861, at the beginning of the Civil War, and became a separate State in 1863. For the origin of the name, see Virginia.

Wisconsin.—The earliest occurrence of the name Wisconsin is by Hennepin, 1695, and has the spelling 8isconsin. 8 is for ou. Some of the early recordings start the word with m instead of with 8. It was evidently the name of the Wisconsin River, or of some place on the Wisconsin River. The name apparently means "grassy place" in the Chippewa language. Wisconsin was made a Territory in 1836 and received its name from the Wisconsin River. Wisconsin became a State in 1848.

Wyoming.—The name Wyoming is from the Delaware language, of Algonquian stock, and means "large prairie place." The original reference is to the Wyoming Valley in Pennsylvania where the Wyoming Massacre took place and where the city of Wilkes-Barre is now situated. The poet Campbell wrote a long and famous poem entitled "Gertrude of Wyoming." When it was desired to give a name to the territory that was formed in 1868, the widely known Indian name of Wyoming was chosen. Wyoming State was created in 1890.

CANADIAN NAMES OF INDIAN ORIGIN

Canada and five Canadian province names are of Indian origin and so are included in this study.

Jacques Cartier in 1545 made a statement as to the origin of the name Canada to the effect that it is a Huron Iroquoian word meaning "settlement." The original form in the language of the Mohawks is Kanaatá, meaning a "small place," in contrast to a town or city.

Manitoba.—The province of Manitoba is named from the large lake of that name which occurs in the province. This lake has, at the center of its hourglass form, narrows that are called, in the language of the Cree Indians who still inhabit these parts, Manitoowaapan, meaning "spirit narrows," that is, dangerous narrows. Lake Saint Anne, "Lake

of Miracles," is called similarly Manitoosaakahikan, "spirit lake," that is, dangerous or miraculous lake.

Ontario.—This name is of Iroquoian origin appearing, for instance, in Mohawk as kanyatariiyú, "nice lake," and as skanyatariiyú, "beyond the nice lake." The former is applied as a descriptive term to Lake Ontario, the latter to the country beyond the lake. The famous Indian, Handsome Lake, was called by the latter of these terms.

Quebec.—The Huron name for Quebec appears twice in the 1632 Huron dictionary of Father Sagard-Theodat. The word is atontaregué, "where the heights of both sides meet together." The Abnaki name is Kabek, from Kab, "to shut," and ek, "place." Hence, "shut in place." The Abnaki name of Quebec first appears in the writings of Samuel de Champlain, who visited the site in 1608, under the orthography Quebecq. Champlain's map gives it as Quebec.

Saskatchewan.—This province gets its name from the Cree Indians. It is the name applied to the Saskatchewan River primarily. Rev. F. J. Calais has analyzed it as Kisiskaatchiwan, meaning "swift river," the first element being the common word for swift, said of a stream, and -tchiwan meaning "river" or "current." Both the north and the south forks of Saskatchewan River fit this description.

Yukon.—The White River in Alaska and Canada was discovered by Robert Campbell of the Hudson Bay Co. and named White by him because of its color. Schwatka says that the Tutchone Indians called it Yukokon Heenah or Yukokon River. The Yuko is a river, tributary to the Yukon from the south about 40 miles above the mouth of the Koyukuk. The native name was reported by Tikhmenief in 1861 to be Yukukakat, i. e., Yuku River. The name Yukon as applied to the main river is of Athapascan origin and has been variously spelled Youcon, Yucon, etc. The etymology is not known but it was possibly applied by extension from the name of one of the headwater streams.

Shanidar Cave, a Paleolithic Site in Northern Iraq

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[With 7 plates]

In contrast to the study of Paleolithic archeology in the West, that of the Orient has lagged behind. This is particularly true of Iraq, a country that has been noted for its archeological discoveries for more than a hundred years. However, it was just about 25 years ago that the first archeological excavation for Paleolithic remains was undertaken there, and until recently no further investigations in this field had been made in Iraq.

In this paper I shall attempt to consolidate the meager information relating to the Stone Age of Iraq in brief outline, with emphasis on my own investigations at Shanidar cave in northern Iraq.[1] The most

[1] On leave of absence from the Smithsonian Institution in 1951, I began the Shanidar cave sounding on behalf of the Directorate General of Antiquities of Iraq while I was associated as archeologist with the University of Michigan's 1951 Expedition to the Near East. Prof. George Cameron was director of the University of Michigan expedition. Returning to Iraq again as a Fulbright Research Scholar, and collaborator of the Smithsonian Institution, I completed the sounding in 1953. The work, financed that season by a grant from the Bruce Hughes Fund of the Smithsonian Institution and again by funds and assistance from the Directorate General of Antiquities of Iraq, was a joint expedition of both institutions. To Dr. Naji al Asil, Director General of the Directorate General of Antiquities of Iraq, who followed the work of the expedition with warm personal interest, and to his institution, is owed a debt of gratitude. Not only did the Directorate General of Antiquities lend financial support to the work at Shanidar at the cost of limiting the budget of their own archeological expeditions elsewhere in Iraq, but they also supplied personnel, equipment, and facilities as needed during both seasons of work.

This report is a preliminary one, since the data are still in process of being analyzed. About one twenty-fifth of the total bulk of the cave deposit was excavated in the two seasons' work. During the first season, the sounding was made October 6–16, November 2–15, and December 14–27, 1951. During the second season the sounding was carried to completion May 9–29, June 6–26, and July 20–August 15, 1953.

outstanding discoveries of the two seasons' work at Shanidar cave are: (1) the adding of a new archeological horizon to the already known stratigraphical relationships in Iraq, and (2) the finding of the Shanidar baby skeletal remains. The latter were found in the Middle Paleolithic (Mousterian) deposits of the cave. The discovery of the skeletal remains marks Shanidar cave as the possible site of the fourth principal Neanderthaloid find spot in the continent of Asia—assuming that the presence of the child's remains in the Mousterian deposit gives it a right to be included in the Neanderthaloid category of races. It is the first Paleolithic skeleton to be recovered in Iraq.

The newly identified archeological horizon, represented by an artifactual assemblage recovered in an Upper Paleolithic stratum, is called the "Baradost" industry.

The name of the present state of Iraq, or 'Iraq, which means "cliff" in Arabic, was the name originally employed after the Arab conquest to designate that portion of the valley of the Tigris and Euphrates Rivers known in the older literature as Babylonia, in the southeast section of old Mesopotamia. Iraq now roughly occupies that geographical portion of the Near East which was called Mesopotamia under the Ottoman Empire, or the "land between the twin rivers" (fig. 1). This is part of Breasted's Fertile Crescent, which has seen the rise and fall of the civilizations of Sumer, Akkad, Babylonia, Assyria, Achaemenian Persians, the Greeks, and the later-day arrivals.

PHYSIOGRAPHY OF IRAQ

The major physiographic features of Iraq today comprise three main natural regions. These include the eastern border of the Arabian plateau (from whose eastern clifflike escarpment is derived the Arabic name for Iraq) which forms the infertile desert region of western Iraq, the valleys of the Tigris and Euphrates Rivers between the plateau of Asia Minor and the Persian Gulf, and the Zagros mountain chain, which rises to 12,000 to 14,000 feet in altitude, enclosing the Mesopotamian Valley in an arc to the north and east.

The Tigris and Euphrates Rivers, the former with its larger tributaries, drain the upper part of Iraq. The general axis of the area of Iraq is northwest to southeast, following the line of the two major river valleys. The lower part of the Mesopotamian plain is almost tablelike in flatness, while the upper part of the country above Baghdad has some topographical relief. In the north there is an extensive dry steppe area with a healthy desert climate, something like that of parts of the American Southwest. There is an unhealthy region of swamps and marshlands in the south, bordered by a desert on the west and the Persian mountains on the east.

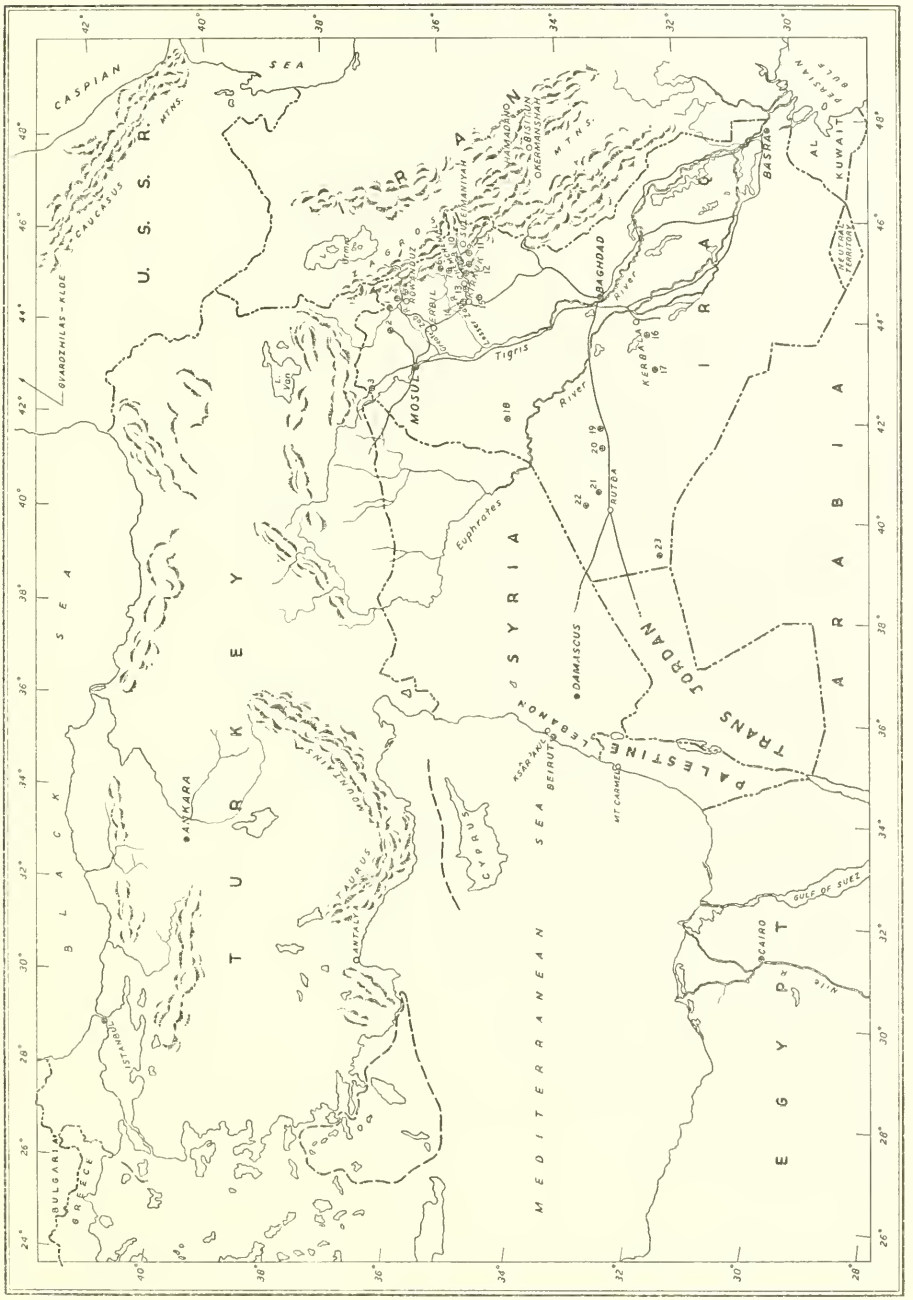


FIGURE 1.—Map of Iraq showing locations of reported Stone Age sites, and neighboring countries. Numbered sites are: 1, Shanidar cave; 2, Aqra; 3, Zakho; 4, Havidan cave; 5, Rowanduz; 6, Dukan cave; 7, Zarzi cave; 8, Palegawra cave; 9, Hazer Merd cave; 10, Karim Shahir; 11, Jarmo; 12, Barda Balka; 13, "Mile 21"; 14, Kirkuk gravels and Baba Gurgur; 15, Tarjil; 16, Tar Kshaife and wadi gravels; 17, site near Shithatha; 18, finds north of Ana; 19, Landing Ground 4; 20, Landing Ground 5; 21, area of Wadi Hauran; 22, Qaara depression; 23, Jebel Anazeh.

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PLEISTOCENE HISTORY OF IRAQ

Very important to our understanding of the Stone Age of Iraq and the Near East is a discussion of the former view concerning the supposed extension of the Persian Gulf in Mesopotamia. Such an extension of this sea would have been an obstacle to the prehistoric migration of peoples. In a recent instructive paper, Lees and Falcon (1952) have demonstrated that Jacques de Morgan's (1924, pp. 32, 39; 1927, p. 2) hypothesis regarding the former extension of the Persian Gulf within the time of man is geologically unfounded. Such a landward encroachment of the sea would have meant that migrant peoples would have had to funnel east and west between the foothills of the Zagros and the northern edge of this water. Lees and Falcon (op. cit.) have found no evidence of marine deposition anywhere in the upper Mesopotamian plain. These authors compiled a study from archeological excavations, boreholes, physical and geological observations, and aerial photography which indicates, contrary to de Morgan's hypothesis, that the Tigris, the Euphrates, and the Karun Rivers are not building forward a normal delta. Instead, these rivers are discharging their load of sediment into a tectonic or sinking basin.

The fact that there never has been a long northward extension of the Persian Gulf within the time of human occupation negates the cherished belief of archeologists, based upon de Morgan's theory, that Stone Age man was obliged to skirt the head of the gulf in the vicinity of northern Mesopotamia. We can now assume that man could have roamed at will, dry-shod, across the length and breadth of the Mesopotamian plains, some actual hint of which is given below.

Very important to the geochronology of prehistoric archeological sites is the identification of old landforms with periods of human occupation. Significant among these landforms are raised sea beaches or marine terraces and inland riverine terraces. Marine terraces are not discussed here, since they are not within the scope of this paper. In fact, there appear to be certain difficulties in correlating marine terraces of the Persian Gulf, into which the principal rivers of Mesopotamia empty, with inland riverine terraces of the same region. Lees and Falcon (1952, p. 28) state that there is no simple development of recent marine terraces in the surroundings of the Persian Gulf, because the folding movements of the anticlines that bound the coasts are still active. There are many sections of subsiding shoreline with drowned valley conditions in synclines and many sloping terraces on the flanks of adjacent anticlines. H. E. Wright, Jr. (1952, p. 24), the geologist who accompanied the University of Chicago Oriental Institute expedition to Iraq in 1951, mentions, among other things, that river terraces traceable to marine terraces were not revealed in his geological reconnaissances in northern Iraq.

In upper Mesopotamia we find the record of distinct terrace systems bordering the Euphrates, the Tigris, and the Greater Zab Rivers. Passemard (1927, p. 71) noted that there were terraces along the Euphrates at elevations of 100, 60, 30, and 15 meters. He found a hand ax described as of upper Chellean type in place in a 30-meter terrace, suggesting that the region was occupied during Lower Paleolithic times.

The geologists of the Iraq Petroleum Co. at Kirkuk reported that one of their surveys between Tarjil and Rudkhana, villages northeast of Tauq in northern Iraq, revealed five fluviatile deposits marking five terraces merging one into another.[2] These terraces lie on the stream drainages of the Tigris River. The relative heights of these terraces above river level were measured between the following limits: Terrace 1, 289 feet; Terrace 2, 190 and 170 feet; Terrace 3, 110 and 90 feet; Terrace 4, 65 and 55 feet; Terrace 5, 33 and 25 feet. The relative horizons of the terraces are constant at about 10 feet for the fourth and fifth terraces, and at about 20 feet for the second and third terraces.

C. Stansfield Hitchin (unpublished report of 1948, pp. 50–51), consulting geologist for the proposed high dam at the head of the Bekhme Gorge in the Rowanduz District of northern Iraq, reports the occurrence of four distinct horizons of terrace gravels above the Greater Zab River. Isolated deposits of these gravels occur at frequent intervals up the length of the Greater Zab and Rowanduz River valleys. These terrace gravels are found at 100–90, 40–35, 15, and 4 meters above the present river level. At many localities these sediments are lime-cemented, and evidently represent the depositions of past pluvial periods, since they contain material far coarser than the present river is capable of carrying, even in flood.

I was able to make a few observations on the terraces in the vicinity of Shanidar village and the Greater Zab River during my explorations at Shanidar cave and environs. Using an aircraft-type altimeter, I measured the heights of two terraces on the Greater Zab River about half a mile above the confluence of the Greater Zab and the Rowanduz River.[3] One terrace lay at approximately 50 feet above the river, and a lower terrace was measured at approximately 25 feet above the river. The Shanidar police post, which is situated on a broad terrace composed of coarse gravel cemented by limestone, is some 140 feet above the river level.

The observations of Passemard, the Iraq Petroleum Co. geologists, Hitchin, and myself are tabulated below (table 1). Measurements made in feet are converted to the nearest meter.[4]

[2] Unpublished data. The terraces are numbered in reverse order in the report.

[3] These readings should be rechecked with a level for more accurate data.

[4] The conversion tables used are the "Express," British into metric conversion tables, by J. Gall Inglis, London, 1927.

TABLE 1.—*Terrace elevations on the Euphrates and tributaries of the Tigris*

Euphrates terraces (Passemard)	Tarjil-Rudkhana terraces (Iraq Petroleum Co.)	Greater Zab and Rowanduz River terraces (Hitchin)	Greater Zab River terraces (Solecki)
Meters		*Meters*	
100	88.0 m. (289 ft.)	100–90	
60	57.9 and 51.8 m. (190 and 170 ft.)		
30	33.5 and 27.4 m. (110 and 90 ft.)	40–35	42.6 m. (140 ft.)
15	19.8 and 16.7 m. (65 and 55 ft.)	15	15.2 m. (50 ft.)
	10.1 and 7.6 m. (33 and 25 ft.)	4	7.6 m. (25 ft.)

These terraces presumably result from climatic fluctuations in the Pleistocene period. As Hitchin notes, the coarser material contained in terrace gravels may be evidence of past pluvial periods. Wright (1952, p. 18) indicates that on the "basis of climatological and physiographical reasoning," deposition may be correlated with either dry or wet climate. In apparent support of Hitchin's suggestion, Wright (ibid.) finds correlation of deposition with relatively humid or wet phases in northeastern Iraq. The nonconformity of several of the readings on the Tigris River drainage may indicate local tectonic movements. With regard to the latter possibility, Lees and Falcon (1952, p. 27) state that in the Mesopotamian region (at least in the southeastern area) the history of recent movements of the mountain zone is shown by terraces in the river valleys leading from the plains into the mountains. The elevation of the mountains was not uniform but episodic.

Thus we appear to have two solutions for the formation of the river terraces within the confines of Iraq. In upper Iraq we find terraces reflecting climatic fluctuations—terraces which must have also been dependent upon episodic elevation movements of the Zagros Mountains. The problem of which factor, climatic fluctuation or tectonic movement, played the dominant role in the formation of the terraces in northern and northeastern Iraq, may be a hard one to solve. That the future holds promise for the establishment of a geological-archeological chronology for the Zagros-Mesopotamian belt is revealed by Wright (1952, p. 24), who states that the relation of the mountain streams to the historical development of the Mesopotamian plain is "susceptible of solution" in a fairly detailed chronological system.

In my own reconnaissance of the Zagros mountain chain in the general area of northern Iraq no evidences of glaciation were seen. This

observation was corroborated by the geologists of the Iraq Petroleum Co., who had not noted any glacial indications in their field explorations.[5] Traces of glaciers have been observed in the Anatolian Mountains by de Morgan (1925, p. 99). A more detailed report on glacial evidences on the Anatolian plateau was made more recently by Erinç, (1949), who noted existing glaciers in the mountains of northeast Anatolia. Flint (1948, pp. 362–363) presents data to show that the mountain areas of western Persia as well as the Anatolian Mountains were glaciated.

HISTORY OF THE PALEOLITHIC ARCHEOLOGY OF IRAQ

The archeology of the Old Stone Age of Iraq is better known in the steppe and mountain areas than in the desert areas or in the region south of a line below Kirkuk. Aside from a few surface finds in the western desert of Iraq and some west of Kerbala, a holy city south of Bagdad, no data have been recovered in the latter area. This is due mainly to the fact that this area has not been explored yet for Paleolithic remains—a truism that holds for a large area of the Near East. The principal investigator of the western desert regions of Iraq is Dr. Henry Field, who collected from many surface sites on the desert plateau west of Bagdad. These collections were made by Field (1952a, pp. 136–139) on motor trips from 1925 to 1928, in 1934, and 1950. The artifacts recovered by Field on his earlier motor trips were studied by Dorothy Garrod, but the work has not yet been published (Field, op. cit., p. 139, footnote 41). In the southwest angle of Iraq on Jebel Anazeh, Field (1952b) found "flint stone implements of Middle and Upper Paleolithic types." He also found artifacts at Wadi Hauran, a long valley near Rutba in the same region. The locus of a number of finds of Old Stone Age material is a large depression (Qaara) about 20 miles north and east of Rutba (Field, 1951, p. 89). In presumably the same area M. Rene Wetzel found flints which appear to be of archaic Neolithic type (Fleisch, 1952, pp. 214–216).

There are in the collections of the Iraq Museum some surface finds of Paleolithic-appearing flints recovered on desert landing grounds of western Iraq. The finds were made by Squadron Leader G. S. M. Insall (now Group Captain, V. C., M. C., retired) of the Royal Air Force in 1927. The specimens were found on Landing Grounds 5

[5] From Iraq comes information that Dr. Herbert E. Wright, Jr., with the 1954–1955 Oriental Institute expedition in the Near East, discovered evidences of glaciers in northern Iraq which had flowed down to 5,000 feet elevation. The relation of gravel terraces of glacial origin to some archeological sites were to be studied. (Released by permission of Dr. Robert B. Braidwood in a personal communication dated February 9, 1955.)

and 4, between Landing Grounds R and H, and on Landing Ground H, on the air route between Habbaniyah and Jordan.

Some flint flakes were found 25 miles north of Ana by a member of the Iraq Petroleum Co. oil prospectors (Field, 1951, p. 89).

Field (1952a, pp. 44, 136–137) reports that he found typologically Paleolithic implements at widely separated points across the face of Kurdistan Iraq. The finds include implements recovered in the Kirkuk gravels, and in the mountain passes at Zakho, Aqra, and Rowanduz, and at Suleimaniyah. He found "hundreds of microlithic implements" on the talus slope in front of Havdian cave, a few miles to the northwest of Rowanduz (Field, 1951, p. 90). Field (op. cit., pp. 89–90) also reports a few flakes near Erbil, and a flint hand ax and some choppers near "mile 21" on the Kirkuk-Suleimaniyah road. Some implements were recovered by the Directorate General of Antiquities of Iraq and Field at Barda Balka on the same road.

W. B. Lucas, of the Iraq Petroleum Co., picked up several flints near Kirkuk which appear to have a Paleolithic cast.

The first Paleolithic finds in northeastern Iraq were made in 1928 by Dr. Dorothy A. E. Garrod (1928) during the course of a preliminary survey undertaken on a joint expedition of the Percy Sladen Memorial Fund and the American School of Prehistoric Research. She recovered several Mousterian artifacts on the surface of gravel beds near Kirkuk, and found (op. cit.) Mousterian-type artifacts on the surface of a small wady near Tarjil, a few miles southeast of Kirkuk. A small flint tortoise core was found in place near the base of a bed of gravel that had been cut into by a stream. It would be interesting to relocate the Tarjil site and try to correlate the gravels with one of the terrace systems mapped there by the Iraq Petroleum Co. geologists.

Dr. Garrod's (1930) expedition to the Sulcimaniyah area of Kurdistan Iraq was the first to conduct a Paleolithic excavation in Iraq. They discovered the Upper Paleolithic ("Gravettian") site of Zarzi, and the Middle Paleolithic (Mousterian) site of Hazer Merd, both of which are cave sites. At Hazer Merd, efforts were concentrated on the excavation of one of six caves, called the Dark Cave. This cave yielded the Mousterian-type artifacts that form the type specimens for this period in Iraq. The expedition excavated a little less than two-thirds of the deposit, and established the presence of three layers: A, B, and C. Layer C, which contained the Mousterian artifacts, had a thickness ranging from 50 cm. to 3.90 m.

It is suggested that the Dark Cave of Hazer Merd was occupied during a cold period, or at least a period colder than today (Garrod, op. cit., p. 40). Yet Dorothea M. A. Bate's (*in* Garrod, op. cit., pp. 38–39) examination of the animal remains reveals (though not in

refutation of this statement) that there was no form represented in the excavation that could not be found living in the country at present.

The cave of Zarzi which Garrod (op. cit.) excavated is a small chamber situated on a tributary of the Lesser Zab River. The main archeological deposit consisted of two layers: A and B. Layer B contained the Upper Paleolithic "extended Gravettian industry," which marks Zarzi as the type station for this horizon. Layer B had a thickness of 50 cm. to 1.50 m. Flint implements representing a single unmixed archeological industry were scattered in great abundance throughout Layer B. The only apparent sign of change or development was the appearance of microlithic geometric forms in the uppermost part of Layer B. The distinctive forms that set this site apart are small round scrapers, bladelets with deeply notched edges, and blunted-back blades (Garrod, 1953, p. 22). There are also a very few single-shouldered points. The microlithic forms from the top of the layer consist of lunates and elongated triangles, with a single microburin. These microlithic forms are typologically Mesolithic in character.

Archeologists of the Directorate General of Antiquities of Iraq recovered some Paleolithic implements on the surface of the desert southwest of Shithatha near a great depression west of Kerbala (Solecki, 1954, p. 62, footnote 1). A representative of the same institution made a reconnaissance of cave sites in the Surdash District of northeastern Iraq, but in none of these were found Paleolithic remains (Mahdi, 1950). It is very likely that some of these caves had been examined earlier by Robert A. Franks, Jr., and F. Turville-Petre, who accompanied Garrod (1930, pp. 41–42) on her expedition in this region.

Barda Balka, an important open Paleolithic site on a hilltop and hillside about 2½ miles east of Chemchemal in the Kirkuk liwa, was originally described by Dr. Naji al Asil (1949). The site was tested during a reconnaissance by Drs. H. E. Wright, Jr., and Bruce Howe (1951) of the Oriental Institute expedition, on behalf of the Directorate General of Antiquities. It seems to have been a living area as well as a workshop site. The investigators made a discontinuous trench about 50 meters long and 1 to 2 meters deep. The artifacts recovered in the Barda Balka gravel may be grouped in three general categories: hand axes, pebble tools, and flakes. The outstanding archeological feature of this site is the combination of cores, pebbles, and small flake implements in the same occupation area, apparently contemporaneous. This material resembles elements in the Acheulian, Tayacian, and Mousterian industries. The assemblage was found in situ, or virtually in situ, on the basis of the geological evidence. It may be considered as the oldest type of industry so far found in a

geological context in Iraq. According to Wright (1952, p. 12), the deposits containing the artifacts date from the very beginning of the last of the four glacial stages of the Pleistocene (i. e., Würm, in terms of the Alpine sequence). Included in the mammal remains are the bones of rhinoceros and Indian elephant, which have not been noted elsewhere in Iraq archeological sites (Wright and Howe, 1951; Fraser, 1953).

The combined archeological expedition of the Oriental Institute of the University of Chicago and the American Schools of Oriental Research under the directorship of Dr. Robert J. Braidwood in 1950–51 spent a season in the region between Chemchemal and Suleimaniyah in northeastern Iraq. This expedition investigated four sites: Jarmo, Karim Shahir, Palegawra, and Barda Balka (described above). All these sites are in the foothills area of the Zagros Mountains. With the exception of Jarmo, a very early Neolithic site, all are pre-Neolithic in age.[6]

Palegawra, a cave site that was excavated by Howe (Braidwood, 1951a, b), is situated about 20 miles east of Chemchemal. Three successive natural layers were exposed in a trench excavated to 1.75 meters. The bottom layer contained an "uncontaminated blade-tool industry, with microliths" resembling the industry of the Zarzi cave (Braidwood, 1951b, p. 15). A preliminary impression is that the industry of Palegawra represents a slightly later phase than that of Zarzi (Garrod, 1953, p. 23, footnote 3). In typological classification it may be deduced that Zarzi and Palegawra are very late Upper Paleolithic sites, bordering on Mesolithic (Garrod, 1953, p. 22; Movius, 1953, p. 416). Unfortunately, because of its physical nature, Palegawra cave cannot be related to the geological sequence of the Chemchemal Valley, and therefore cannot be placed in the geochronology of this area (Wright, 1952, p. 12). There is no way of geologically dating Zarzi cave either.

Karim Shahir is an open settlement site of about 2 acres in extent, situated on an eminence about one-fourth mile upstream from Jarmo (Jarmo is about 5 airline miles east of Chemchemal) (Braidwood, 1951a, b). It was excavated by Bruce Howe. This site appears to represent the terminus of the Mesolithic quite close to Early Neolithic Jarmo. Karim Shahir had a single occupation exposed in about 550 square meters of area, with the principal occupation level only a

[6] Braidwood (1952, p. 41), and Braidwood, Robert J. and Linda, 1953, pp. 279–280) use the term "food gathering stage" as a substitute for the Paleolithic; "era of incipient agriculture and animal domestication" for the Mesolithic; and "era of village-farming efficiency" for Neolithic in their papers on Near Eastern archeology. According to the Braidwoods, the terms in current usage, especially Neolithic and Mesolithic, are felt to be too loosely applied.

few centimeters below the modern surface. The site is chronologically and typologically between Jarmo of the village-food-raising period and the Palegawra cave, of the earlier hunting-foraging period. Some kind of house structure is suggested, and the recovery of a small number of sickle blades, milling stones, and a fair number of chipped and ground stone hoes is pointed to as evidence for the beginnings of agriculture. Also in the inventory are chipped celts with polished bits; ground stone rings, bracelets, and pendants; in addition to a large proportion of microliths.

Karim Shahir, as well as the succeeding Jarmo, belongs to a dry climate in the "Post-Glacial climatic optimum" of the European climatic sequence (Wright, 1952, pp. 22–23). The faunal remains of Karim Shahir reflect this dry climate.

In summarizing the history of Paleolithic archeology in Iraq, it is evident that with the exception of Shanidar cave, the leading sites of pre-Neolithic Iraq are situated in an area approximately 35 miles wide in the foothills of the Zagros Mountains between Chemchemal and Suleimaniyah. These sites include Barda Balka, the Dark Cave of Hazer Merd, Zarzi, Palegawra, and Karim Shahir. There are gaps in the archeological sequence, which future investigations will inevitably close.

It is certain that with further and more systematic searches in the desert areas of Iraq, more Stone Age sites will be found. Since Lees and Falcon's study (1952) has shown that the supposed former extension of the Persian Gulf into Mesopotamia was not a fact, we may assume that Stone Age man moved at will across the length and breadth of this region. It is possible that Paleolithic sites may be buried under the alluvium of the Tigris and Euphrates Rivers and their drainage systems in southern Iraq. The desert regions, as in the other desert areas of the Near East (notably Kharga Oasis in Egypt), had a more favorable climate, presumably in pluvial times, thus supporting enough game to attract the hunting-foraging peoples of the Paleolithic period. There are several depressions of large size in western and southern Iraq, around two of which Paleolithic-type artifacts have been recovered.

Affinities of the Mousterian industry of the Hazer Merd cave have been found by Garrod (1930, p. 37; Garrod and Bate, 1937, p. 119) with the caves of Palestine. The assemblage from the Bisitun cave in western Iran contains elements that are comparable to the industry from the Hazer Merd cave also (Movius, *in* Coon, 1951, pp. 91–92; Movius, 1953, pp. 414–415).

At the time of Garrod's (1930) finds at Zarzi, information from Russia was scanty; the nearest comparable sites were the Austrian loess stations and the Grimaldi caves. With new reports from Rus-

sia, she realized that the Kurdistan industry of Zarzi, although possibly later in time, should be linked with the industries of Kostenki I and Gagarino, some 600 miles to the north. The microlithic assemblage from the upper part of Layer B of Zarzi cave resembles the flints from the cave of Gvardzhilas Klde in the Caucasus, a site that also dates from the very end of the Paleolithic (Garrod, 1938, p. 14). Garrod (1953, pp. 22–23), in a recent view of the problem, feels that this "culture is for the moment too isolated to enter into a general picture of the Middle Eastern sequence." On the other hand, Waechter (1952, p. 16) finds a marked similarity of the upper part of Zarzi to the post-Aurignacian of Palestine, as well as to the site of Gvardzhilas Klde.[7] For Palegawra, with an industry similar to, but somewhat later chronologically than Zarzi, the same relationships presumably hold.

Karim Shahir yielded a Mesolithic industry which Howe regards as a development from the Zarzi-Palegawra stage, but definitely later in time (Movius, 1953, p. 417).

Prior to the discovery of the Shanidar cave, the superposition of a very late Upper Paleolithic industry such as that of Zarzi upon the Middle Paleolithic of the Hazer Merd cave left a chronological and cultural hiatus unaccounted for. It represented a tremendous jump—presuming a change-over in the climate, physiography, biology, as well as in the flint-working tradition—as though one wiped the slate clean and began all over again. We can be pretty sure that the racial types of Paleolithic man (about which we still know nothing in Iraq) had changed too, as at Mount Carmel in Palestine.

SHANIDAR CAVE

Shanidar cave, first explored on an archeological reconnaissance in 1951 (Solecki, 1952a), lies in the Rowanduz district of the Erbil liwa, in northern or Kurdistan Iraq (fig. 2). The Chemchemal-Suleimaniyah area is about 120 airline miles to the southeast of Shanidar. The village, after which the cave has taken its name, is occupied by a small tribal settlement of Barzani Kurds, who had been resettled there by the Iraq Government. Shanidar village is 29 miles by road from Khalifan, a Kurdish village on the main road to Ryat from Erbil. A police post, one of the several that are to be found at points along the roads in this region, dominates the terrace edge above the Shanidar village.

The synclinal valley of Shanidar lies at about 1,400 feet (426.7 meters) elevation (pl. 1, *a*). It is formed by two rivers, the Greater

[7] For additional references concerning possible relationships of the Zarzi site with this Caucasus site see Movius, 1953, p. 416, especially footnote 25.

Zab River flowing southeastward, and the Rowanduz River, flowing northwestward. These two rivers join at a village called Der Tesu in the valley, where they cut across the Berat Dagh mountain at the Bekhme Gorge. The Greater Zab River, one of the major tributaries of the Tigris River, originates in the Anatolian plateau. The Rowanduz River, originating near the eastern boundary of Iraq, emerges into the valley from the famed Rowanduz Gorge of Hamilton (1937).

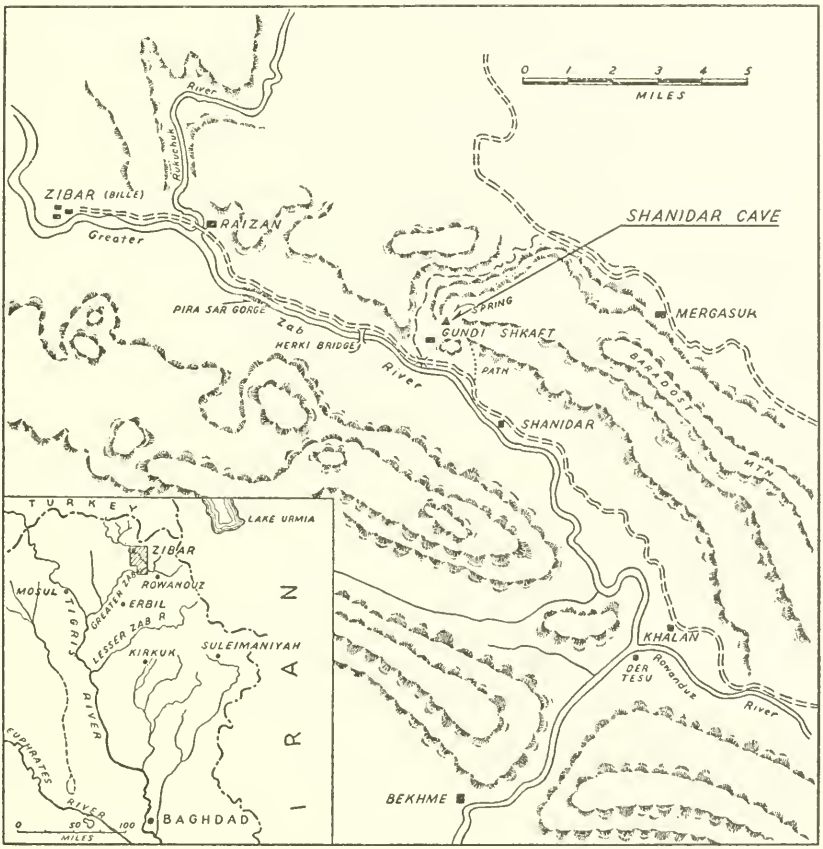


FIGURE 2.—Map showing location of Shanidar cave in the Zagros Mountains of Kurdistan Iraq.

The valley of Shanidar nestles behind the second range of mountains (Berat Dagh) from the Mesopotamian steppe area. Baradost Mountain flanks the valley on the northeast. Both mountains are over 6,000 feet (1,828.8 m.) high. These mountains are part of the system of parallel and subparallel anticlinal folds of the Zagros Mountains. In the vicinity of Shanidar there is a directional curve of these mountains from a general northwest-southeast direction to a more westerly trend in conformity with the Zagros arc. Several gravel terraces are present in the valley, which have been judged to

be pluvial in origin. Baradost Mountain looks down upon the Shanidar valley with a steep southwest-facing scarp attaining precipice elevations along much of its length. Stunted dwarf oak trees dot the landscape in the river bottom which has a rather broken floor of some 1½ miles in width.

The valley of the Greater Zab River between Zibar, a village to the northwest of Shanidar, and Shanidar village is constricted above Gundi-Shkaft (an abandoned village site) at the Pira Sar Gorge. The valley in the Zibar area above this gorge is called the Sapna or Sapne Valley (Wigram and Wigram, 1914, p. 311). It is in the area of this gorge, a scant 2 miles from Shanidar cave, that the migratory Herki Kurds twice seasonally construct their log, branch, and twig bridge across the Greater Zab River for their annual migrations to the Persian mountains for the hot summer months, and return. It seems likely that before the present road was cut along the left bank of the river the only trail led past the Shanidar cave. In fact, some groups of these migrant Kurds still do use this trail in preference to the road. There are evidences of "Kor Pasha's road" below Shanidar cave. This road, which leads from Rowanduz to Mosul (it is said), was built by one of the Kurdish rulers who had his seat at Rowanduz over a hundred years ago.

Shanidar cave (Kurdish, Shkaft Mazin Shanidar—cave big Shanidar) is a solution cave in a dolomitic Qamchuga [8] limestone series of Middle Cretaceous age. The color of the rock is a light gray-brown, which erodes into a reddish-colored soil. There is a fault zone near the cave with two well-marked fault lines, parallel to the axis of the mountain folds.

The cave is situated at about 2,200 feet (731.5 m.) above sea level, or about 1,200 feet (365.8 m.) above river level. The Greater Zab River may be seen a mile and a half from the cave (pl. 1, *b*). Shanidar cave is in a sheltered nose of the Baradost Mountain, facing the south with a warm, sunny exposure, and protected from the winter winds (pl. 2, fig. 1). There is an intermittent stream which flows at the foot of the slope to the west. This stream bed contains stagnant pools in its lower portion during the dry summer months. There is a path following the upper reaches of this stream through a steep valley to Mergasur, a village on the east side of Baradost Mountain. It takes about two hours to make this journey. A closer supply of water than the intermittent stream is to be found in the springs up the gorge from the cave some 410 feet (125 m.) by a well-traveled path. Water is carried in goatskin bags on the backs of the present cave-dweller women, as their forebears had probably done before them at Shanidar.

[8] Called Qamchuga by the geologists of the Iraq Petroleum Co., and Judea limestone by Hitchin (unpublished report of 1948).

The mouth of the cave is shaped roughly like a broad triangle (pl. 2, fig. 2). The opening measures 82 feet (25 m.) wide, and 26 feet (7.92 m.) high. Not far from the opening the width increases abruptly toward the interior to an extreme of 175 feet (53.34 m.). The ceiling vaults loftily to a jagged crevice about 45 feet (13.2 m.) above the cave floor. From this point inward the ceiling falls away rapidly to a height of 25 feet (7.62 m.), then gradually slopes to the rear until the end of the cave is met, some 130 feet (39.62 m.) from the cave mouth. The talus slope, with its yearly mounting debris, is steep, slanting away to the gulley about 140 feet (42.67 m.) below (figs. 3, 4).

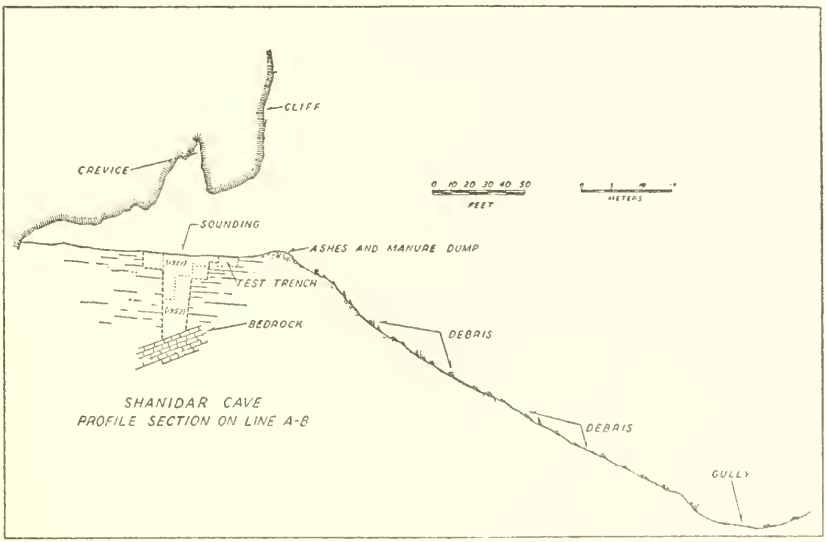


FIGURE 3.—Section of Shanidar cave showing extent of 1951 sounding (dotted line) and 1953 sounding (dashed line).

Between the colder winter months of November and April, a group of Shirwani Kurds, about 35 people in all, or approximately 7 families, inhabit the cave. They maintain small single-roomed winter shelters constructed of log posts, branches, twigs, and straw ranged around the sides of the cave interior. Each of these is warmed by a stone-bordered open fire. Completing the scene of communal living are the animal corrals for the goats, and hitching posts and tethering stakes for the larger animals such as the cows and horses. It is apparently customary for these cave inhabitants occasionally to light a large communal fire, burning cakes of earth (observed during the 1951 season). These cakes are compacted segments of animal dung and humus-containing cave-floor crust, which burn with a hot flame for a long time. The sizable ash deposit left may account for the phenomenon of large ash and fire remains in the topmost layer (Layer A)

of Shanidar cave. The recovery of a number of small, well-attrited pieces of flint on the surface of the talus slope was explained when it was observed that the cave dwellers—even the workers (when matches were lacking)—strike flint and steel for fires and for the lighting of pipes and cigarettes.

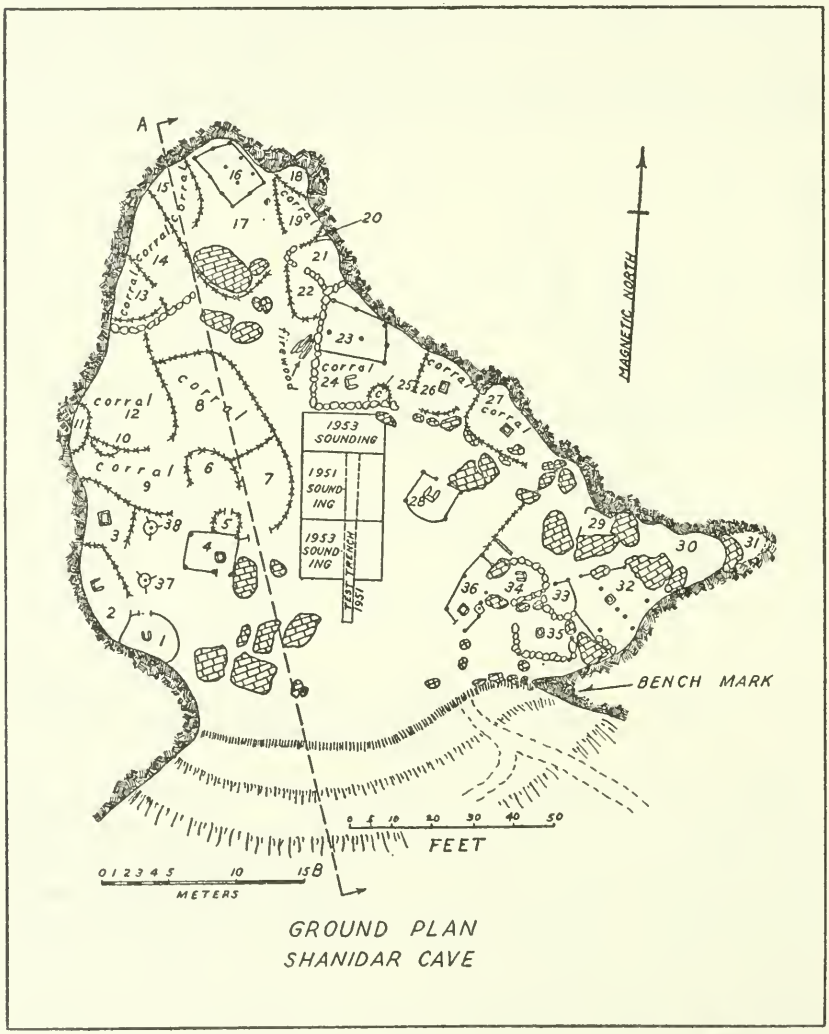


FIGURE 4.—Plan of Shanidar cave showing extent of the 1951 sounding and expanded limits in 1953. Of the enclosures indicated, Nos. 1, 2, 3, 4, 24, 26, 27, 28, 32, 34, 35, and 36 were houses or had been formerly used as houses by present-day Kurdish inhabitants. The rest of the features, with the exception of 37 and 38, were animal corrals or storage places. Features 37 and 38 were leban (Kurdish, "mast") or milk-product churn tripods.

Two seasons were spent in the sounding of the deposits, in 1951 and 1953 (Solecki, 1952b, 1953a, b). The first expedition, which was undertaken on behalf of the Directorate General of Antiquities of

Iraq, was engaged on the project for more than 6 work weeks during the fall and winter of 1951. Ahmad Mahdi, a staff member of the Directorate General of Antiquities, represented his institution at Shanidar the first season. Excavation was begun with a test trench in the middle of the cave floor area. As the results of this preliminary assessment seemed to be very promising, a grid plan of 5 feet (1.52 m.) was staked out for the areal control of the sounding (fig. 5). A

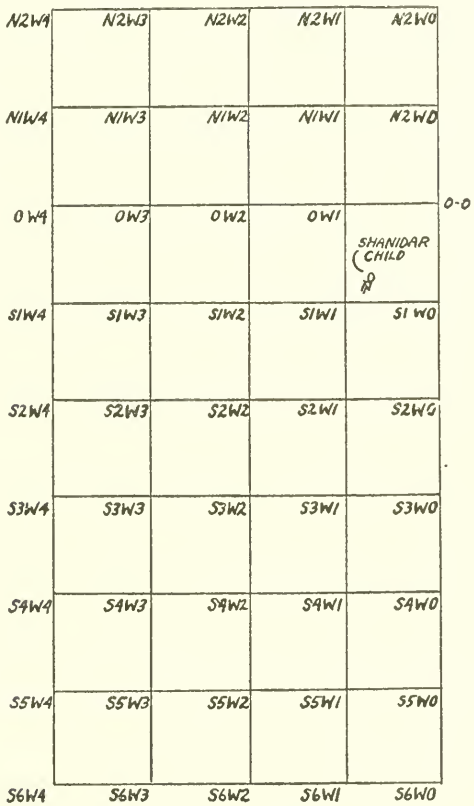


FIGURE 5.—Grid plan of Shanidar cave sounding.

datum plane for vertical or depth control was established. The sounding was excavated and screened by 6-inch (15.24-cm.) levels. The 1951 sounding measured 15 by 20 feet (4.57 by 6.10 m.) in ground plan, with a depth reaching to 25 feet (7.62 m.) in the deepest area. The sounding was "stepped" back.

Four major cultural layers were recognized as the result of the first season's operation: Layers A, B, C, and D, from top downward (pl. 3, *a*, *b*; figs. 6, 7). Layer A, marked by a thick accumulation of ash beds, hearths, and organic-stained soil, contained modern, historic through probably "Neolithic" horizons. Layer B, a thinner zone of

brown stained soil, yielded a nonceramic Zarzi type of flint industry, including a Mesolithic-like industry (pl. 4). Layer C, which the writer (Solecki, op. cit.) had earlier called "Aurignacian" and "Aurignacian-type," contained a stone industry which was later identified as unique (pl. 5). Layer D contained a typologically Mousterian stone industry which, with the exception of hand axes, is typologically similar to the industry recovered by Garrod at Hazer Merd (pl. 6). These layers with their contents and significance are

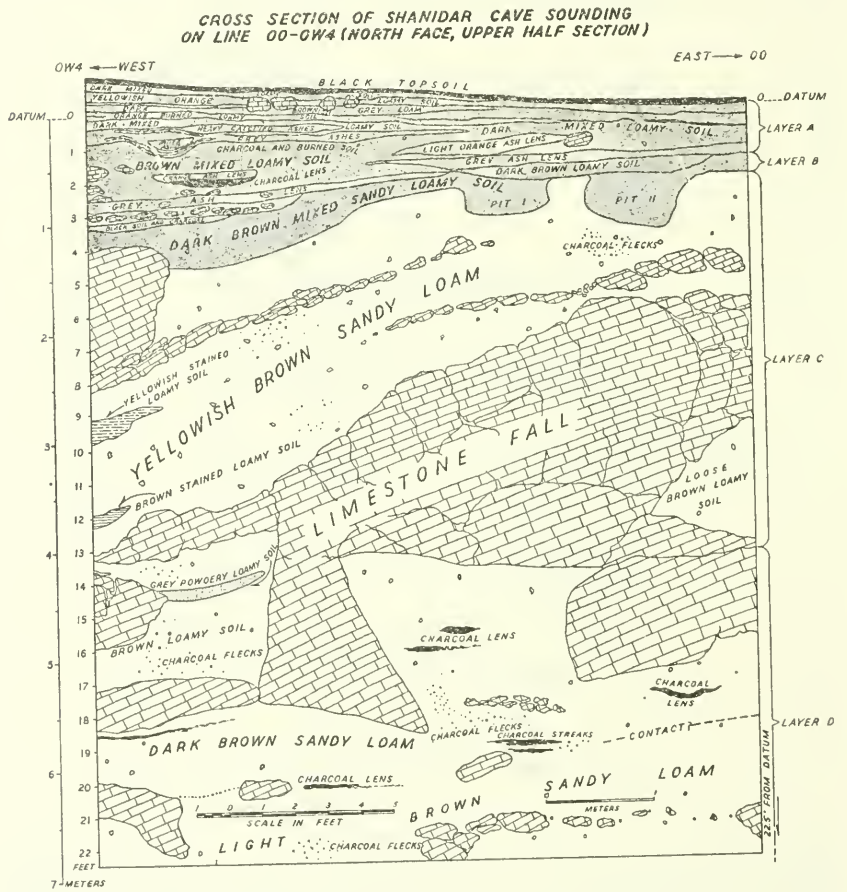


FIGURE 6.—Upper part of the north face of Shanidar cave sounding, 1951 season, showing Layers A, B, C, and the upper part of Layer D.

discussed in more detail below. It may be well to emphasize here that the four cultural layers noted do have soil changes within them, but for the present treatment I chose to recognize the layers in broad physical as well as cultural perspective, placing weight on typological contexts (e. g., Layer D, a very thick deposit, while it appears to be typologically Mousterian in content throughout, is not composed of a single unbroken soil stratum, as one should logically expect).



a, View of Shanidar Valley to the southeast from a point near Shanidar cave. The Greater Zab River, with its terraces, at the right; Baradost Mountain, a part of the Zagros mountain range, in left background. *b*, View to the south and west from the mouth of Shanidar cave. The Greater Zab River is just beyond the notch in the hills in the foreground.



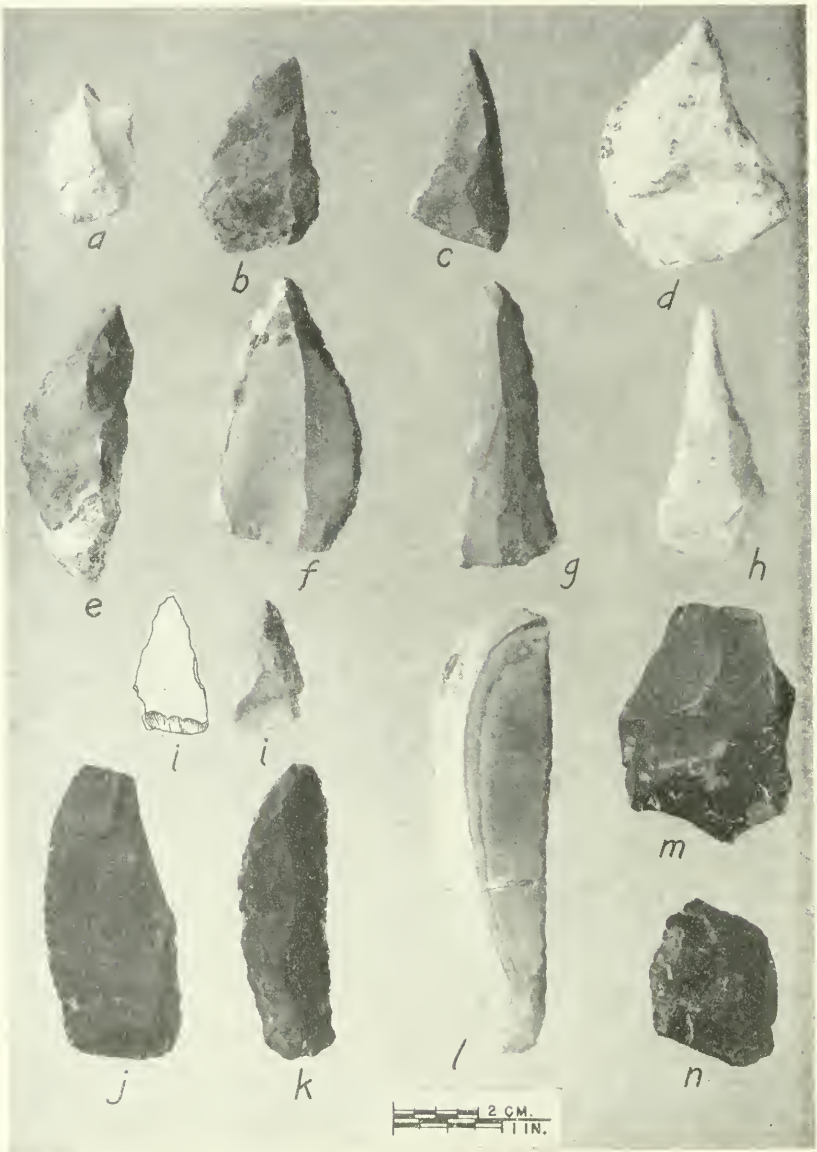
1. Looking north toward Shanidar cave. The structure on the right side of the cave interior is one of the several habitations of present-day Kurdish tribesmen.



2. View from the interior of Shanidar cave. The excavation is in the foreground.



a, North face of Shanidar cave sounding, 1951 season. The westward slant of Layers A, B, and C is shown. *b*, Lower part of Layer D in Shanidar cave sounding, north face, 1953 season. The man is standing on bedrock. The heavy occupational zone containing the layer of stalagmitic crust is indicated.



Examples of flints from Layer D (Middle Paleolithic, Mousterian) of Shanidar: *a*, Borer or perforator; *b*, *c*, curved or asymmetric points, no faceted striking platform; *d*, curved or asymmetric point, faceted striking platform; *e*, double-ended keeled point; *f*, point, no faceted striking platform; *g*, *h*, points, faceted striking platform; *i*, Emireh-type point, two views; *j*, side scraper; *k*, side scraper and end scraper; *l*, side scraper; *m*, "exhausted" medium flake core; *n*, "exhausted" small flake core.



The Shanidar child. The pin points approximately north.

The second season, under a grant from the Smithsonian Institution and with funds and assistance contributed by the Directorate General of Antiquities, a joint undertaking was resumed at Shanidar cave. Hussein Azzam represented the Directorate General of Antiquities that season. During a period of 10 workweeks in the summer of 1953, the sounding was continued down to solid bedrock. The pit was

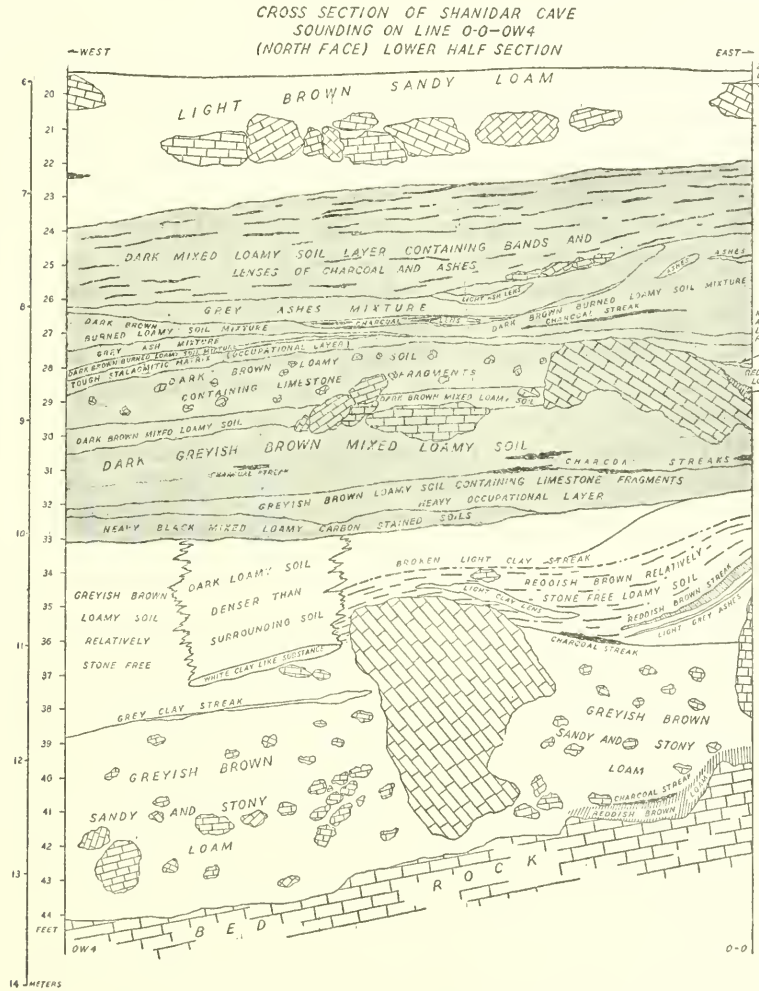


FIGURE 7—Lower part of the north face of Shanidar cave sounding, 1953 season, showing the heavy occupational zone in Layer D.

enlarged from its previous dimensions in ground plan to an area of 20 by 40 feet (6.10 by 12.19 m.), and "step-backs" were enlarged, reaching down into the main shaft. The bottom of the main shaft measured 20 by 13 feet (6.10 by 3.96 m.) in areal section, and bedrock was reached at a maximum depth of 44 feet (13.41 m.) in the

western portion of the sounding. It slanted upward to the east to a depth of 31 feet (9.45 m.) below the surface.

The engineering of the sounding presented the usual problems with respect to excavation and soil removal, plus constant vigilance against possible cave-ins. The deposits below Layer A were composed of compact loamy soils which were safe enough for the maintenance of steep wall faces. Encountered were numerous boulders and stones which had to be broken up into portable-sized fragments for clearance. These undoubtedly had fallen from the ceiling. A total of 41 charges of gelignite were set in order to shatter the larger boulders. This activity presented some difficulties during the winter season of 1951 when the whole cave population of natives with their livestock had to be evacuated before each blast.

A slight earthquake, a factor normally not included in the calculations, was experienced on August 14 while work was in progress at the bottom of the pit. Fortunately, the walls held and no damage was done to either the personnel or the sounding.

The number of flints recovered during the 1951 and 1953 seasons total approximately 2,800 specimens. Of this number, over 40 percent are use-retouched flakes and blades, notched blades and flakes, cores and core fragments. Layer B in the stratigraphy yielded the most flints for its shallow deposit, numbering well over 1,000 specimens. Of the remainder, Layer D yielded the next in numerical proportion, while Layer C produced the least number of specimens.

Except for a study collection presently in the Smithsonian Institution, the whole collection from Shanidar cave is in Iraq.

This preliminary announcement of the two seasons' work at Shanidar is based upon my first reports (Solecki, op. cit.), my notes and observations of the collection that is now in Baghdad, and a sample of the flints studied in this country. The last represents approximately a selected 10 percent of the flint inventory. Drs. J. W. Amschler of Vienna and F. C. Fraser of the British Museum have kindly consented to examine the mammal bones. Dr. Alexander Wetmore of the Smithsonian Institution has agreed to examine the bird bones. The reports from these authorities will be included in a later paper. Dr. Hans Suess of the U. S. Geological Survey has taken three carbon specimens (from Layers B and C) for carbon-14 analysis. His findings are reported below. The sum total of the related biologic, climatologic, and geologic findings (or as much as can be obtained) will be treated in the final report.

STRATIGRAPHY

It was observed that the top layers, A and B, were shallower in depth in the northeast part of the sounding, growing deeper toward the

western and southern part (pl. 3, *a*). This slant in these deposits was due principally to a large boulder and fallen stones in the northeast quarter. The boulder was capped with a comparatively thin veneer of Layers A and B, and in part Layer C. The boulder was actually within Layer C. The top limit of Layer C, conforming to the dip of Layer B, also sloped sharply to the west. The demarcation line between Layers C and D was only slightly slanted to the west. This latter slant was very likely due to the dip of the bedrock to the west and north, to which the base of Layer D conformed.

Layer A.—This horizon was uncovered below a 2-inch (5.08-cm.) crustal capping of dry compacted topsoil and dung. The layer contained a thick series of large, widespread, colored ash beds and hearths lying in a matrix of dark, organic-stained soil. The deposit was thicker in the western part of the sounding (8 ft., 2.44 m.) and thinner in the eastern part (2 ft., 60.96 cm.). Rock-lined fireplaces and hearth stones were encountered throughout this layer. A pit occurred in the eastern part, in which were found the scattered fragmentary remains of a human burial. Unfortunately, the bones—those of an adult—were few in number. A copper bracelet of Islamic type and two spiral copper beads were found closely associated with one of the human bones, discoloring the latter with verdigris.

It was early evident that Layer A had intruded into Layer B, mixing some of the artifactual materials at the junction of the deposits. In the top part of Layer A were found, in addition to a quantity of recent potsherds, some clay pipe fragments, which are evidence of the introduction of the smoking habit to this area. According to Yacqub Sarkis (1941) the smoking habit was introduced into the Near East about 300 years ago. The potsherds, numbering upward of 3,000 fragments, occurred in greatest profusion toward the middle of Layer A, where fragmentary mammal bones were also found in greatest abundance. With the exception of some reddish burnished Uruk sherds, no pottery types were immediately recognizable in the collection. The sherds consisted almost exclusively of culinary wares. It would seem that a statistical study of the potsherds will have to be made in order to evaluate the collection properly, if at all. The major difficulty is that no excavations of tells (talls) have been made in this district from which comparative studies of sherds may be made. It may be possible to compare statistically the culinary sherds, which were associated with the various identified wares (Hassuna, Ubaid, Uruk) from the Diyan and Bastoon caves on top of Baradost Mountain (Safar, 1950), and to evaluate the results in terms of the Shanidar-cave pottery.

The artifact inventory from Layer A appears to represent a cultural backwater of the higher civilizations to the south. As an anal-

ogy, one might compare the simple economy and habits of the present tribal goatherds, who seasonally inhabit the cave, with contemporary life in Bagdad or in any other sizable city in Iraq. Rotary quern fragments (found exclusively in the upper part of Layer A) and hand manos and boulder mortars found in this layer attest a somewhat sedentary life, with some dependence on cereal foods, nuts, and the like. The introduction of the rotary quern must have been quite a recent technological revolution in these Kurdish hills. Both rotary querns and boulder mortars were used by the present inhabitants of the cave while work was in progress during the 1951 season. Among the flints, which were found in the lower mixed junction zone of Layer A, are cores, notched blades, use-retouched blades, end scrapers, steep scrapers, microlithic flints, and blunted back blades and bladelets. No sickle blades were found. Hammerstones, rubbing stones of black and green shale, and lumps of hematite, worked bones including well-made awls and pins, and one grooved shaft or rod smoother of stone similar to the one recovered by Garrod (1930, fig. 11) at Zarzi, represent the rest of the inventory.

Layer B.—Layer B was composed of a soil zone in marked contrast to Layer A. The thick and heavy organic ceramic-containing deposits were absent, as were the enormous compressed hearths and ash beds, and the profusion of mammal bones. There is clear-cut evidence that Layer B had been reduced in true thickness by the intrusion of Layer A in the upper part of the former. Adding to the complexity of Layer B, it was found that this layer had in turn intruded into the upper part of Layer C. Layer B was a deposit of dark brown, sandy, loamy soil, slanted in depth from east to west. The thickness of Layer B was approximately 2 feet (60.96 cm.) in the eastern part, and 5 feet (1.52 m.) in the western part. Four small pits and a large depression intruded from Layer B into Layer C. The purpose of these features was not ascertained. Not evident in the 1951 season, but noted in the 1953 season, was a difference in soil texture in Layer B, marking an upper and a lower division of this layer (figs. 8, 9). Whether or not this division represents a true occupational difference, which might be indicative of a cultural change and reflected in the artifactual assemblage, is still to be worked out. It will be recalled that Garrod (1930) found a microlithic component at Zarzi in the upper part of the layer, a fact that hints at developmental change there. The Zarzi industry and the Layer B industry of Shanidar (in addition to artifacts in the lower mixed zone of Layer A) are typologically the same, with some slight variation.

The artifact inventory from Layer B includes among the rough stones items such as hammerstones, rubbing stones, and mullers. An ovate pebble with a V-shaped notch cut across its upper face is among

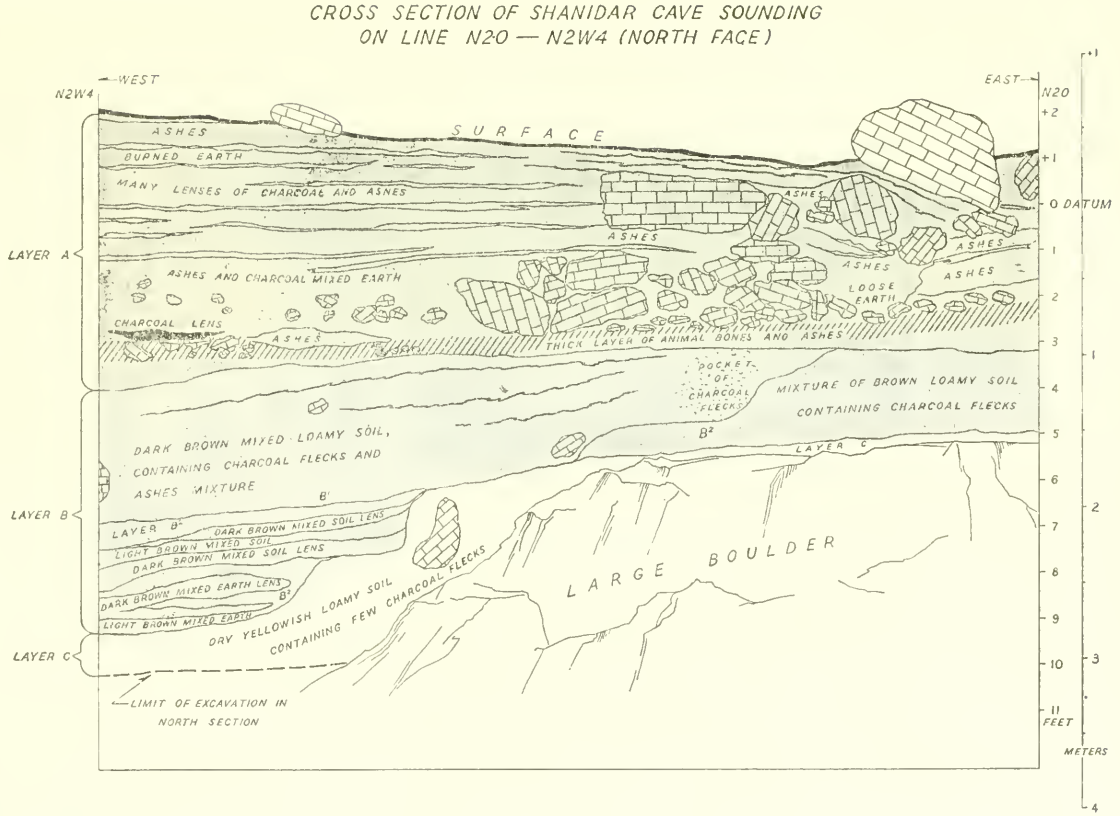


FIGURE 8.—North face of step-back in the upper part of Shanidar cave sounding, 1953 season. Layer B appears to have an upper and a lower division (B^1 and B^2).

the specimens found (fig. 10, *d*). The flints, like those of Zarzi, reflect a very careful and expert chipping industry. Small river cobbles of chert were evidently used. The color of the material ranges from light tan, reddish through brownish, to green and gray chert. Layer B had proportionally the largest number of pieces of worked obsidian, an exotic material, the nearest source of which is in the Lake Van

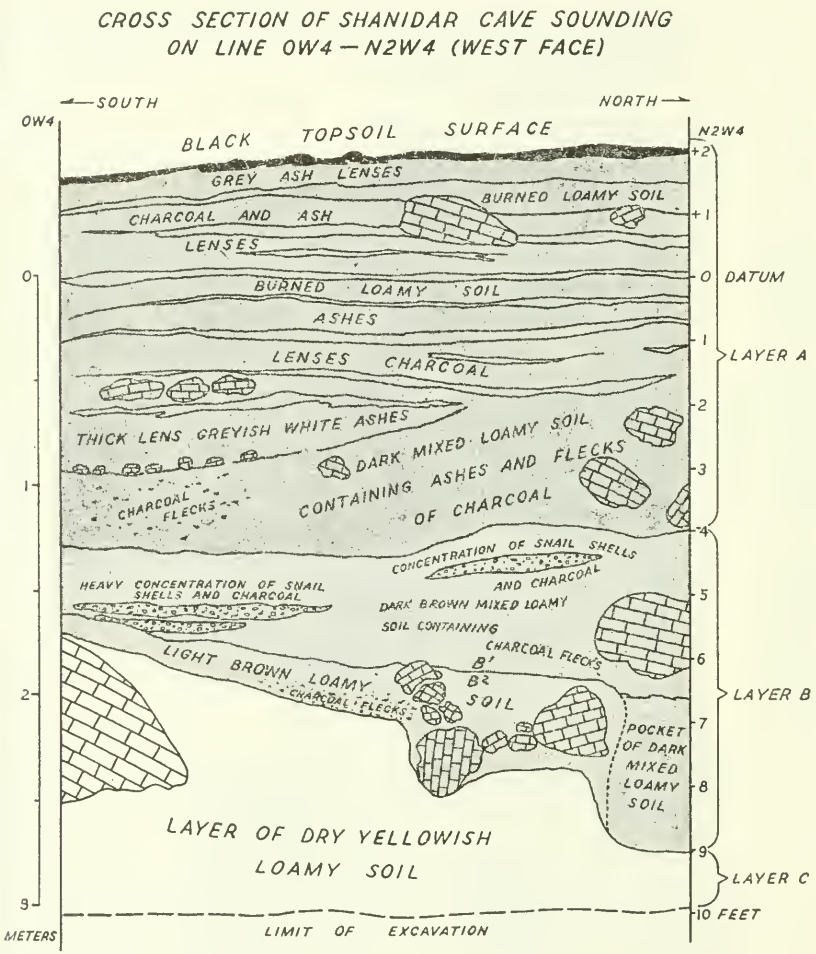


FIGURE 9.—West face of step-back in the upper part of Shanidar cave sounding, 1953 season. Layer B appears to have an upper and a lower division (B^1 and B^2).

region of Anatolia. In the assemblage are several "Gravette" points, several types of gravers, backed blades and bladelets, elongated triangular and subtriangular or scalene points, several single-shouldered points, a small number of lunates and trapezoidal forms (including a Kebaran and Heluan crescent), borers or perforators, core scrapers, side and end scrapers, notched blades (including "lames étranglés"),

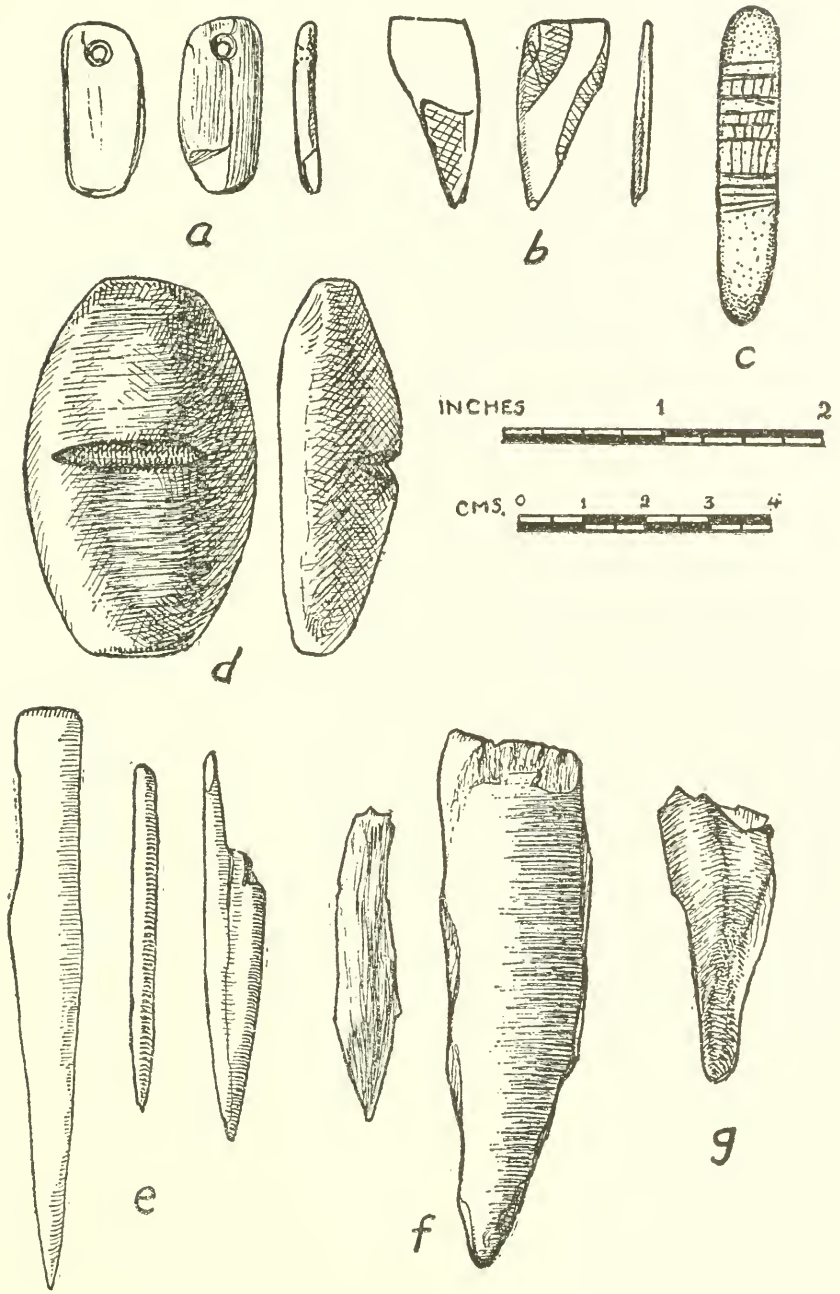


FIGURE 10.—*a*, Layer B, shell pendant; *b*, *c*, Layer B, inscribed slate; *d*, Layer B, grooved and rubbed planoconvex gray stone; *e*, Layer B, one bone pin and two bone awls; *f*, Layer C, two pointed bones; *g*, Layer D, pointed and sharpened bone.

and retouched blades and flakes. An unusual object was a small, flat, ovate slate pebble bearing a scratched cross-hatching on its face (fig. 10, *c*). One small shell pendant was also recovered (fig. 10, *a*). Worked-bone implements were relatively plentiful. These ranged from simple bone splinters with sharpened points, to carefully polished, long, slender pins (fig. 10, *e*).

I feel that there are strong typological resemblances between certain flints from Coon's (1951) Belt cave and Shanidar B. Coon's (1952) Hotu cave, also in Iran, while lacking the finer distinctive forms, such as the trapezoids, subtriangles, and others, similarly appears to have a very late upper Paleolithic flavor—even Mesolithic (Dupree, 1952, p. 257, footnote 1). If not Shanidar B in character, the artifacts of Hotu are quite close to it in affinities. From the bottom of Layer B (or B^2, figs. 8, 9), Suess obtained a carbon-14 date on a charcoal sample (W–179) of 12,000±400 years or about 10000 B. C.

Layer C.—As previously stated, Layer B had intruded into Layer C, a much thicker deposit. This resulted in some confusion of artifact types in the very top of Layer C and the bottom of Layer B. The top of Layer C increased in depth below the surface to the west, and in this respect it conformed with the westward dip of Layer B. Layer C had a thickness of 13 feet (3.96 m.) in the eastern part of the sounding, and 10 feet (3.05 m.) in the western part. In the northern part of the sounding—an area which was most intensively explored in the 1951 season—Layer C was composed principally of a relatively organic-free, yellowish-brown, sandy loam. A large number of limestone boulders and stones, representing at least two falls from the cave's ceiling, were encountered. Evidence of human occupation, such as traces of charcoal, hearths, and artifactual materials, were found among these stones. Not until the season of 1953, when the southern portion in the "step-back" was explored, was it fully realized that the major occupational stratum of Layer C was contained south of the boulder complex. There, hearths and ash lenses were clearly marked in detail in the dark, organic-stained soil. The implication is that the cave dwellers naturally preferred a boulder-free living-room area. Some of the boulders must have formed a sort of shelter, since hearths were found within what must have been small, overhanging, protective nooks of limestone blocks. There is abundant and conclusive evidence that all the dangers were not outside the cave. The falls of limestone must have interrupted life around the hearths, for more than one hearth was found underneath a boulder, its normally flat lens compressed and contorted out of shape by the weight of the stone. The heaviest fall of stones was encountered in the northern part of the sounding near the bottom of Layer C. The occupational traces in the upper part of Layer C were relatively light in

comparison with the evidence of human occupation toward the bottom of this layer.

Hearths were found to range in size from about a foot (30.48 cm.) in diameter and a few inches thick, to over 10 feet (3.05 m.) in diameter and nearly 6 inches (15.24 cm.) thick.

The artifacts inventory from Layer C, while comparatively poor in proportion, is singular, since apparently it has no counterpart known thus far in the Near East. Included among the flints are several types of gravers (including one of special form that is described below), perforators, fabricators, scrapers of several types including circular scrapers, points, notched blades, and use-retouched blades and flakes. It was essentially a blade-tool industry. A couple of ferruginous pebbles were found. There were only a few worked bones (fig. 10, *f*). The majority of the latter were from the upper part of the layer. It appears that blades and blade cores were more abundant near the upper part of Layer C. Also more numerous in the top part of Layer C were the notched blades. Several backed blades found in the top part of the layer were evidently intrusive from Layer B. Points on long, narrow flakes, like the Mousterian type, occurred near the bottom of Layer C.

Upon examination and consultation with Garrod, who viewed the collection in Bagdad in December 1953, the assemblage from Layer C was thought to deserve a new distinguishing identity. Certainly the forms represented in this layer at Shanidar are not characteristic of a western Aurignacian industry. Nor has another assemblage like this one been described from anywhere in the Near East, exclusive of Iraq. It was decided to call the industry of Layer C the "Baradost" industry, after the name of the mountain which looms so prominently above Shanidar. At best, measured in terms of stone industries, the Baradost industry is a relatively poor one.

Layer C is characterized by its high proportion of well-made gravers, among which are a small number of a distinctive form. The latter are a variant of a polyhedric graver.[9] The departure from the ordinary type of polyhedric graver, as described by Burkitt (1949, p. 62), are two opposed angular notches on the cutting edge. These notches were intentionally formed by blows directed on the end of the blade producing a chisel-like projection or nose that is flanked by a

[9] J. Bouyssonie, of Brive, France, in a personal communication dated January 15, 1955, writes that this type of graver is known from the Aurignacian in France. The first type described here he would call "burins-carénés-museau" (nosed keel-shaped gravers). The second type, with the single shoulder, he would call "burins carénés à épaulment" (shouldered keel-shaped gravers). M. Bouyssonie prefers to reserve the term "polyhedric," on typological grounds, for another variant of keeled graver.

step or notch on either side—quite different from the ordinary gouge type of polyhedric graver, which has a convex working edge. In addition, there are in the collection several single-notched variants of the polyhedric graver. The net effect is a rather flat, narrow, working edge which was probably trimmed to limits desired by the toolmaker. This certainly was a specialized form of tool that must have filled some needed purpose or adaptation. In the collection of the artifactual materials from Ksâr 'Akil, near Beirut (Lebanon), which is now housed in the Peabody Museum at Harvard University, seven examples of these artifacts were noted (unpublished data). These come from about the 9-meter level of the site, which lies within the horizon described by Ewing (1947, p. 191) in a preliminary announcement as "Lower Aurignacian" or "Châtelperronian."

Two samples of carbon from Layer C were given to Dr. Suess for radiocarbon dating. Both samples were from extensive hearths. The first sample (W–178) was from near the upper part of Layer C in Square S3W1 at a depth of 10.0 feet (3.05 m.). This sample gave a carbon-14 date of 29,500±1,500 years, or about 27500 B. C. The second sample (W–180) was from near the lower part of Layer C in Square S2W4 at a depth of 15.0 feet (4.57 m.). This sample gave a carbon-14 date older than 34,000 years, or beyond the range of the radiocarbon dating method used by Dr. Suess.

Regarding the great chronological lapse between the lower part of Layer B (see above) and the upper part of Layer C, it is very likely that the boulders and falls of limestone lying in and above Layer C had effectively sealed off portions of the occupational horizons of Layer C.

Layer D.—The contact line between Layers C and D is distinct at a depth of 16 to 17 feet (4.88 to 5.18 m.) from the surface in the southern face of the sounding. The relationships were difficult to determine in the northern part of the sounding because of the boulders. There was no sterile soil intervening. Layer D, which upon preliminary analysis appears to contain a homogeneous Mousterian-type industry similar to Hazer Merd, represents a long occupation of the cave. Its thickest part measured 28 feet (8.53 m.). Limestone boulders were encountered at intervals in this deposit, but there were no large widespread falls as in Layer C. The soil was a light-brown to yellowish-brown sandy loam, with a heavy occupational zone through the middle. This stratum, which may later warrant a separate identity within Layer D, was marked by mixed, dark organic-stained soil containing extensive hearths and ash lenses across the whole area section of the sounding (pl. 3, *b*). An unusually heavy and deep concentration of large hearths consisting of banded lenses of ashes, charcoal, and burned earth was found in the east wall between the depths

28.0 feet (8.53 m.) and 32.0 feet (9.75 m.). This hearth zone measures about 5 feet (1.52 m.) across and 4 feet (1.22 m.) deep. The deposits are concaved, or downwarped, as though there had been a hollow in this particular part of the occupational area. There is no appearance of intrusional disturbance except in the bottommost part of this feature. The marked concentration of hearths in this unique localized zone gives this feature a pitlike appearance. Fragments of mammal bones and flints were found in it. The stratum mentioned above, and within which the hearth zone occurred, had an average thickness of about 9 feet (2.74 m.). The stratum lay between the depths of 23 to 32 feet (7.01 to 9.75 m.) from the surface. It was the richest part of Layer D in cultural material, and it was in this heavy occupational zone that the Shanidar child was found at a depth of 26 feet (7.93 m.) from the surface. A continuous stratum of lime-cemented deposit about 5 to 6 inches (12.70 to 15.24 cm.) thick occurred at a depth of 27 to 28 feet (8.23 to 8.53 m.); it slanted across the sounding within the heavy occupational zone. This was the only lime-cemented or stalagmitic deposit in the sounding, and may represent an interval of increased (or exceptional) humidity in the geochronological sequence at Shanidar.

Above and below the heavy occupational zone in Layer D were found small scattered hearths and other archeological evidence. As in Layer C, some of the hearths were contorted and compressed out of shape by fallen boulders.

Flints were found on the bedrock floor of the cave, indicating that Shanidar cave had been host to Stone Age man from the very beginning of the sedimentation.

The Shanidar child (pl. 7) was uncovered in the southwest quarter of Square S1W1 at a depth of 25.8 feet (7.81 m.) below datum, or about 26 feet (7.93 m.) from the surface. It was discovered when one of the workmen began to scrape some loose earth from this area preparatory to the excavation of another level.

The skeleton was found in a dark gray-brown loamy soil. It rested 3 inches (7.62 cm.) above a bed of light-gray ashes. Search for a burial pit met with negative results. Flecks of charcoal were noted in the surrounding earth. The child was found in a flexed or doubled position, with its head oriented to the north. All the bones present were in articulation. The feet and leg bones were doubled to the west or right side of the child, and the arm bones were similarly flexed to the same side. The head, which was badly crushed, presumably by the overlying earth, faced upward. All the bones, except those of the extremities, were in a very poor state of preservation. They were friable and badly decomposed, and many fragments were reduced to a powdery state. However, we are exceedingly fortunate that so much

remained to be recovered. The writer had observed during the course of the sounding that the moist, loamy earth was not especially good for bone preservation, and that many of the fragmentary mammalian bones in the same stratum as those of the child were very poorly preserved.

The legs may have been doubled upward originally, and twisted to the side by the overlying earth. The length of the burial on the long axis measured 1 foot ¼ inch (31.12 cm.). Its greatest width, across the lower extremities (from the feet to the pelvic girdle), was 7½ inches (19.05 cm.). The skeletal remains were about 1¾ inches (4.45 cm.) thick at the maximum section. The arms were poorly preserved and defined, but sufficient bones of the right hand remained to show that the fingers of that hand had been closed with the palm upward. The pelvic girdle and vertebrae were very poorly preserved and could not be saved. The rib bones had disappeared.

A careful search around the remains revealed no associated artifacts with several possible exceptions. A small block-shaped fragment of limestone lay at the left heel. Adjacent to this stone was found a small nodule of black carboniferous substance measuring one-half inch (1.27 cm.) by three-quarters of an inch (1.91 cm.). A large flint was found 2 inches (5.08 cm.) to the east of the head, and a fragment of a mammal bone was found an inch (2.54 cm.) to the east of the left knee. Another smaller fragment of burned bone was found near the right arm. These bones and the flint appear to have been part of the normal occupational layer, and not items meant to be associated with the child's remains. However, it is possible that the piece of limestone and the associated carboniferous substance may have been intentionally interred with the remains. The mixed, dark loamy-earth stratum in which the skeleton was found abounded in occupational debris, and included fragments of mammal bones, flints, flecks of charcoal, and fragments of limestone. The limestone fragments were not abundant by comparison with the amounts encountered from other depths. The unbroken lens of a firebed lay at a depth of 24.5 feet (7.47 m.) below datum, just about over the child's remains, which precludes the possibility of an intrusive burial. The skeleton must be identified with the stratum in which it lay.

The skeleton is represented by 68 bones and bone fragments. There are 8 finger bones and finger-bone fragments; 11 whole and fragmentary left leg bones and metatarsals; 18 whole and fragmentary right leg bones and metatarsals; and 31 cranial fragments. Sixteen milk teeth are represented, including 4 first incisors, 3 second incisors, 3 canines, 3 first molars, and 3 second molars.

Since the bones have not been studied anatomically in detail, or compared with other Paleolithic finds, no statement can be made con-

cerning the morphology of the Shanidar child. According to Dr. D. F. Veldkamp, professor of dentistry at the Royal College of Dentistry in Bagdad, the teeth, by modern standards, would appear to belong to a child about 9 months old. The cranial fragments seem to be thicker than the normal for a child of that age. Although it may be possible to reconstruct the calvarium from the fragments preserved, the face is, unfortunately, beyond reconstruction, since none of the facial parts were recovered. The teeth are the best-preserved parts of this individual, and it is expected that much can be learned from them, even though they are not adult.

The heaviest concentrations of artifactual materials were found clustered around two horizons within the heavy occupational zone of Layer D. One of these was at about 24 to 27 feet (7.32 to 8.23 m.), and the other was at about 30 to 31 feet (9.14 to 9.45 m.) from the surface. Very few worked bones, including bone points, were found (fig. 10, *g*). In greatest abundance were the flint points and scrapers. The points were both symmetrical and asymmetrical in shape, the former being proportionally more numerous. The majority of the symmetrically shaped points appear to be relatively broad and flat, or narrow with thick, keeled cross sections. Among the asymmetric curved points only one good example of a curved-backed point was found. Side scrapers made on broad flake blades were very abundant. There was a small percentage of borers and notched flakes. At least one limace (slug-shaped flint) was present. A fairly large percentage of simply retouched points on flakes was found, suggesting that the stone artisans were quick to take advantage of a likely-shaped flake. A preliminary check of the collection shows that no gravers are present in the series. Garrod (1930, p. 35) found four at the cave of Hazer Merd, together with two hand axes, which were not present at Shanidar. Another point of difference with Hazer Merd is that, whereas no cores were found there (Garrod, op. cit., p. 33), a fair number were recovered at Shanidar. These were rather amorphous-shaped, and of medium to small size. There is a surprisingly poor showing of discoids, or cores that may be classed in the discoid category. It would seem that material was scarce, and the core was broken down or exhausted to the last flake that could be extracted. As at Hazer Merd, the raw material evidently consisted of river pebbles of medium size, which probably accounts for the relatively small size of the artifacts. The use of the prepared striking or faceted platforms was known. It may be stated tentatively that the flakes were struck off with end blows, not side blows.

On first impression, with the exception of the gravers and the hand axes, the flint artifacts of Hazer Merd cave could be matched type for type with examples from Layer D. Furthermore, there is a

marked similarity in the stone industry from Bisitun in western Iran (Movius, *in* Coon, 1951, pp. 91–92) to the flints from Layer D at Shanidar. In fact, there is almost a 100-percent agreement with Movius' analysis of the Bisitun cave material.

Some very special finds, which did not occur at Hazer Merd or in Iran, were four Emireh-type points.[10] Three of these were recovered between 25 and 26 feet (7.62 and 7.93 m.) deep in the heavy occupational zone of Layer D, about one-third of the way down in this horizon. By a remarkable coincidence, the Shanidar child was found in the same level. A fourth point was recovered at a depth of 28 to 29 feet (8.53 to 8.84 m.). According to Garrod (1951), who found Emireh points at the base of the Upper Paleolithic at Mount Carmel, the Emireh point is part of a transitional industry between the Levalloiso-Mousterian and Upper Paleolithic industries in Syria and Palestine. Although Emireh-type points from Shanidar were found in a stratum some 9 feet (2.74 m.) below the contact zone between the Upper Paleolithic (Baradost) and the Mousterian of Layer D, there seems to be some indication of contemporaniety of the Shanidar examples and those from Mount Carmel in Palestine on the basis of the climatic evidence. Thus the lime-cemented zone at about 28 feet (8.53 m.) in Layer D at Shanidar may indicate a period of increased rainfall, which was closely followed by the level containing the Emireh-type points, while a pluvial period, or a period of greater humidity, also occurred immediately below the Emireh horizon at Mount Carmel. In fact, the Emireh horizon was almost entirely broken up by the water action (Garrod and Bate, 1937, pp. 22–27; Garrod, 1951, pp. 121–122; 1953, p. 31). In the Lebanon at Ksâr 'Akil, Ewing (1947, pp. 191, 195) found points of Emireh type just above a complex of stone beds. He suggests that this complex of stone beds is indicative of a period of "greatly enhanced humidity and precipitation" (Ewing, *in* Braidwood, Wright, and Ewing, 1951, p. 120). Wright's (*in* op. cit., p. 119) work at the same site shows that its cultural deposits, including the geological stone complexes, may be safely dated as "entirely Würm." Garrod (1953, table, p. 38) has illustrated the relationship of the Emireh horizon, or "Emiran" period, in a geochronological table for Palestine and Lebanon. The place of the alluvium (representing a pluvial period) below the "Emiran" horizon in the Würm glaciation is a matter of interpretation between

[10] In a personal communication dated January 12, 1955, Dorothy Garrod states that she does not consider these points to have any necessary connection with the Emireh points on typological grounds, despite resemblances in the basal chipping. Nevertheless, I feel at this writing that the closeness of the association of the Shanidar points with a presumed contemporaneous pluvial horizon favors the case of relationships.

prehistorians of the schools of long and short chronologies (Caton-Thompson, 1952, pp. 20–21). According to the former school, this pluvial (Pluvial 2 in Caton-Thompson's study) may be correlated with Würm I, while, according to the latter, it may be correlated with Würm II. Regardless of which chronology is used, for our considerations it appears that the evidence for the contemporaneity between the horizon of the Emireh-type points of Shanidar and the "Emiran" of Palestine and Lebanon is satisfactory. Since the Shanidar child was found in the same level as the Emireh-type points, it must belong to the same archeological horizon. The Emireh points being indicative of a transitional industry (Garrod, 1951), the Shanidar child then belongs to the same transitional phase. Whether or not the Shanidar child will ever fill the evolutionary gap between *Homo sapiens* of the Aurignacian of Palestine and the "human type which is morphologically intermediate between Neanderthal and modern man" of the Levalloiso-Mousterian of Mount Carmel (Garrod, 1951, p. 129) remains to be seen. The prospects are tantalizing.

The enigma here is the 8 or 9 odd feet (2.44 or 2.74 m.) of typologically Mousterian deposit lying above the Emireh-type point level at Shanidar. Excluding the possibility of independent invention, we presume that the Emireh-type points were culturally introduced from the eastern Mediterranean region (unless the weight of more evidence indicates another locus of origin). This sounds plausible enough, since there is only a distance of about 600 miles between these areas, unbroken by difficult barriers. Yet the people of Shanidar at that time, or at least in succeeding ages, must have indeed been cultural laggards. Whereas in Palestine and at Ksâr 'Akil we find a fully developed Upper Paleolithic immediately following the introduction of the Emireh industry (the latter development even being allocated a place in the lower Upper Paleolithic (Garrod, 1953, p. 38)), at Shanidar, it may be tentatively stated, there is no evidence of the new tradition until the appearance of the Baradost horizon. The people of that remote time at Shanidar cave seem to have been just as reserved and aloof in their mountain fastness as are the present Shirwani Kurdish goatherds.

The tentative correlations of the Stone Age horizons in Shanidar cave with the known sequence in Iraq are given in table 2. If they were present at Shanidar, the stages above and including Karim Shahir and Jarmo must fall in the time interval between the end of Layer B and the most recent deposits at Shanidar, or within Layer A. However, a preliminary analysis of the remains in Layer A reveals that there are but few links in this layer with the more recent archeology of Iraq. Furthermore, since the Paleolithic cultures of Shanidar cave have been emphasized in this paper, the discussion of the Layer A phases will be deferred for the present.

TABLE 2.—*Correlation of the archeology of Shanidar cave with the archeology of Iraq (tentative)*

Archeology of Iraq	*Archeology of Shanidar Cave*
Recent Historic Dynastic Early Dynastic Proto-literate Neolithic and Early Neolithic	(?)— Layer A —(?)
(?) Palegawra	(?)
Zarzi	Layer B
(Late Upper Paleolithic and Mesolithic ?)	(10,000 B. C. ±400 years)
(?) (Upper Paleolithic)	(?) Layer C (Baradost) (27,500 B. C. ±1,500 years) (Older than 34,000 years)
(?) Hazer Merd	(?) Layer D
(Middle Paleolithic) (?) Barda Balka (Middle and Lower Paleolithic)	

In conclusion, a recapitulation of some first impressions of the Paleolithic archeology of Shanidar cave might be noted. In Iraq, the typological similarity of the very late Upper Paleolithic (bordering on Mesolithic) flint assemblage of Layer B of Shanidar to the industries of Zarzi and Palegawra caves is apparent. Also evident is the apparent typological similarity of the Middle Paleolithic Mousterian flint assemblage of Layer D of Shanidar to the Mousterian industry of the Hazer Merd cave and the Bisitun cave. Layer C, containing the Baradost industry of the Upper Paleolithic, is a unique one.

Outside Iraq there appears to be good typological evidence of linkage of Shanidar cave with the west—or the eastern Mediterranean area—throughout its Paleolithic history. Thus, the assemblages from the upper part of Zarzi (Shanidar B), and Hazer Merd (Shanidar D) have been noted to bear affinities with material from the Palestine-Syria area. Further support of these resemblances may be made on an individual basis with special items in the Shanidar cave material, i. e., with "index fossils" (since detailed typological comparison studies of the artifacts have not yet been made). Admittedly scanty yet significant clues are the presence of a Kebaran-type and a Heluan-type point in Shanidar B—artifact types found in the Mesolithic of the eastern Mediterranean. A special type of polyhedric burin in the Baradost industry of Shanidar C has counterparts in the "Aurignacian" industry of Ksâr 'Akil of Lebanon. Last, we find the presence

of "Emireh-type" points in Shanidar D associated quite closely with a stalagmite level or evidence of a pluvial period—a phenomenon also noted in Palestine-Lebanon. The typological resemblances of the Shanidar Paleolithic material are not exclusively alined with the eastern Mediterranean region. Affinities have been noted with the caves of Iran and archeological sites in the Caucasus. Outside of Kökten's (1949) finds in the Korain cave near Antalya in Turkey (material comparable to Shanidar D),[11] we do not have good comparison studies with Anatolia, a region where close relationships should be sought.

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[11] My impression of Kökten's "Mousterian II" material, viewed in Ankara, is that this assemblage is comparable to Shanidar D. It contains a large proportion of points and side scrapers, similar to the situation at Shanidar.

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Medicine, Warfare, and History[1]

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It is not commonly realized that many of the most significant advances in medical science have been made by medical officers in the armed services or by civilian physicians working under the stimulus of wartime exigency. Whereas the ultimate compensations of war to any society are usually few and seldom recognized, in the field of medicine, over the years, they have been numerous and many of them highly important. A number of examples may be cited from the historical record.

In his illuminating series of notes on the history of military medicine, the late Col. Fielding H. Garrison[2] made the observation that, while there were military surgeons in ancient times who occupied positions of responsibility and respect in the armies of Greece and Rome, it was the Swiss Confederation, in the fourteenth century, that antedated all other nations of modern Europe in state care of the wounded. Municipal ordinances were issued notifying the individual soldier that his government was behind him and would look after his welfare on the field of battle. The eminent historian Conrad Brunner[3] points out further that, from the time of the battle of Laupen in 1339, the Swiss archives are replete with records of monies distributed for the care of the wounded and their dependents. Brunner also discovered that barber-surgeons were engaged by individual Cantons to attend the wounded after battle. The Swiss thus set an example to all the other warring countries of western Europe.

In France in the 1470's we find that Charles the Bold, Duke of Burgundy, had placed a surgeon in each company of 100 lancers, that is, one surgeon to 800 men. It is also recorded that the lancers received £12 monthly from the Duke's coffers while his surgeon-physi-

[1] Reprinted by permission from the Journal of the American Medical Association, vol. 153, Oct. 3, 1953.

[2] Garrison, F. H., Notes on the history of military medicine, Mil. Surg., vol. 50, p. 1, 1922.

[3] Brunner, C., Die Verwundeten in den Kriegen der alten Eidgenossenschaft: Geschichte des Heeressanitätswesens und der Kriegschirurgie in den schweizerischen Landen bis zum Jahre 1798, Tübingen, 1903.

cians received only £5. When Edward IV of England joined Charles the Bold in the campaign against Louis XI, he brought with him a chief physician, two "body physicians," a surgeon, and 13 assistant barber-surgeons. These men, who attended the sick and wounded, gained valuable experience for dealing with civilian problems, injury, and disease when the wars had ended.

A century later we find Andreas Vesalius, founder of modern anatomy, serving as a military surgeon in the armies of Charles V. His contemporary Ambroise Paré, who lived through the reigns of seven French monarchs and served four of them, not only introduced the ligature for arresting hemorrhage resulting from injury or amputation but also used antiseptic salves for dressing wounds. A man of high character, Paré spoke with authority and did more to place surgery on a modern basis, as Vesalius had anatomy, than any other person until the time of Joseph Lister. Paré was also a pioneer in advancing the art of rehabilitation of the injured. He devised many forms of prosthesis, including wooden arms, legs, mechanical fingers, false noses, and ears—advances that again were adopted by civilian surgeons.

During the seventeenth century and first half of the eighteenth, advancement of military medicine proceeded slowly, and there was no one comparable to Paré until the last half of the eighteenth century, when James Lind, the great British naval surgeon, appeared on the scene. There was, however, one notable figure in the seventeenth century, Richard Wiseman, who served the royalist armies in England throughout the civil war and after the Restoration and who was responsible for many improvements in surgical technique, including the art of amputation, especially in the case of gunshot wounds affecting the joints. His book, "Severall Chirurgicall Treatises," published in London in 1676, is one of the important landmarks in the history of surgery, both military and civilian.

To James Lind, M. D. (1716–1794) (to be distinguished from James Lind, M. D. [1736–1812], also a Scotsman) of Edinburgh, a surgeon long in the service of the Royal Navy, we owe the first clear-cut proof that scurvy can be prevented by the use of citrus fruits among sailors on long ocean voyages. His "Treatise on the Scurvy," published in 1753,[4] is a classic, and as a result of it a dread disease, common not only among seamen but in civilian populations where citrus fruits are not readily available, has been virtually eradicated.

[4] Lind, J., A treatise of the scurvy. In three parts. Containing an inquiry into the nature, causes, and cure of that disease; together with a critical and chronological view of what has been published on the subject, Edinburgh, 1753. Reprinted as Lind's Treatise on Scurvy, Stewart, C. P., and Guthrie, D., editors, Edinburgh, 1953.

Fully conscious of the importance of his discovery, Lind wrote in the preface to the first edition:

> The subject of the following sheets is of great importance to this nation; the most powerful in her fleets, and the most flourishing in her commerce, of any in the world. Armies have been supposed to lose more of their men by sickness, than by the sword. But this observation has been much more verified in our fleets and squadrons; where the scurvy alone, during the last war [ending in 1748], proved a more destructive enemy, and cut off more valuable lives, than the united efforts of the French and Spanish arms.

WILLIAM BEAUMONT AND SILAS WEIR MITCHELL

In 1853 the American medical profession mourned the death of William Beaumont, U. S. Army surgeon, who, in addition to advancing the art of surgery in our armed forces, made a brilliant study of the processes involved in human digestion. When Beaumont was stationed at an isolated army barracks in northern Michigan, a French-Canadian courier, Alexis St. Martin, was accidentally shot through the stomach. Beaumont attended his wound with infinite care. When it healed it left a fistula that Beaumont looked on not as a mere wound but as a unique opportunity to inspect his patient's stomach mucosa by direct vision and to study the rate of digestion of individual foodstuffs through action of the gastric juices. He was also able to remove these digestive secretions and to study their action on food outside the body, a study that resulted in his celebrated monograph, "Experiments and Observations on the Gastric Juice, and the Physiology of Digestion," [5] which so well exemplified Pasteur's famous dictum, "In the field of observation, chance favours only the mind which is prepared."

The United States armed forces have had many other illustrious medical officers who have done original work through opportunity to study wounded men, ours as well as those of the enemy. Many names come to mind, such as that of John Shaw Billings; but no one during the Civil War occupies the position of Silas Weir Mitchell, a physiologist by training and a neurologist through special interest. Mitchell, with W. W. Keen (who ultimately became a celebrated Philadelphia surgeon) and G. R. Morehouse, early in the Civil War (1861) had occasion to study peripheral nerve injuries and the sensory and motor disturbances that result therefrom. Perusal of the protocols of their preliminary Circular Letter issued through the Office of the Surgeon General on March 10, 1864,[6] and of the monograph that they

[5] Plattsburgh, 1833.

[6] Mitchell, S. W.; Morehouse, G. R.; and Keen, W. W., Jr., Reflex paralysis, the result of gunshot wounds, founded chiefly upon cases observed in the United States General Hospital, Christian Street, Philadelphia, Circ. No. 6, Surgeon-General's Office (March 10), 1864. [Reprinted, Yale Medical Library, New Haven, Conn., 1941.]

published later in the same year,[7] makes it clear that Mitchell was the dynamic force behind the study. His analysis of the problem illustrates his powers of observation and his genius for making sound physiological deductions. Among other things, Mitchell and his colleagues discovered that in certain cases following severance of an important nerve, especially when the nerve's disruption was associated with infection, there were abnormal sensory manifestations, i. e., hyperesthesia in the extremity affected, a syndrome that Mitchell named causalgia. The problem of causalgia has been studied for nearly a hundred years in both civilian and wartime cases of nerve injury, and it came to be most actively studied during World War II, when its incidence was frequent.

In retrospect, an even more important contribution of Mitchell and his collaborators lies in the clear-cut description of "primary" and "secondary" shock. Thus, in discussing the various types of shock, one reads in the circular on reflex paralysis (see footnote 6):

> The majority of physicians will no doubt be disposed to attribute the chief share in the phenomena of shock . . . to the indirect influence exerted upon and through the heart. There are, however, certain facts, which duly considered, will, we think, lead us to suppose that in many cases the phenomena in question may be due to a temporary paralysis of the whole range of nerve centres, and that among these phenomena the cardiac feebleness may play a large part, and be itself induced by the state of the regulating nerve centres of the great circulatory organs. . . . But there do exist certain cases, more rare it is true, in which singular affections of the nerve centres, other than those of the heart, occur as a consequence of wounds.

WORLD WAR I

During World War I there were many medical advances stimulated by the war itself, particularly in the sphere of prevention of infectious disease. It is said that when the Austrians attempted to invade the Balkans, the front was held not by guns but by the louse and the devastating epidemics of typhus caused by the jumping creatures. It is estimated that nearly a million Austrian soldiers poised on the Balkan border perished from epidemic typhus. The Russian armies had much the same difficulty and so did those of other countries of western Europe. Our soldiers were similarly troubled in the trenches on the western front, but through use of hygienic methods there was far less devastation.

On the basis of the experience of World War I, every effort was made in World War II to protect our troops from typhus, especially in the Mediterranean theater. Meanwhile, DDT, the most effective insecti-

[7] Gunshot wounds and other injuries of nerves, Philadelphia, 1864; see also Fulton, J. F., Neurology and war (VIIIth Weir Mitchell Oration), Trans. and Stud. Coll. Phys., Philadelphia, vol. 8, p. 157, 1940.

cide then known, had been introduced and was used by the Eighth Army under the direction of General Fox and General Hume to delouse the population of Naples and other points of southern Italy. This practically abolished the typhus hazard among our occupation forces and the Italian civilians.

It would be difficult to enumerate all the special branches of medicine that have benefited by war research, but there is nothing so striking as the protection afforded our troops by mass inoculation, particularly against tetanus. To quote Brig. Gen. Elliott C. Cutler, chief consultant in surgery of the European theater of operations in World War II,

> I would like to speak of the miracle which has occurred in eliminating tetanus from military surgery. Let me recall some figures for you. In our Civil War, the mortality rate was from 89 to 95 percent. Shortly before World War I, under the benefit of antitoxin which was discovered and elaborated upon by the use of animals, the mortality rate had dropped to between 40 and 80 percent. During World War I, large statistical evidence showed a mortality rate of 20 to 58 percent; but, in this second World War, there were only 11 cases known to have occurred amongst 10,700,000 men. Of these 11 cases, 5 had been given toxoid and 6 had not. Moreover, in these 11 cases, there are records of only four deaths, two of which occurred in individuals who had received the basic series of toxoid but no booster dose, and two in individuals who had not received even the basic series. This is, in my mind, one of the great miracles of modern medicine. The basis of the establishment of a proper toxoid rests squarely upon animal investigation, and no greater debt could be acknowledged to our friends in the animal kingdom than this advance for the good of humanity.[8]

In World War I many other lessons were learned, particularly the importance of moving casualties rapidly from the front lines, before infection had set in. The mortality incidence from battle casualties was far less than in the Civil War or the Spanish-American War, but it was still high as compared with the mortality rate from casualties in World War II.

Harvey Cushing took the lead in dealing with head wounds, and, while he worked slowly, much to the consternation of other Allied surgeons, he took the rugged view that one wound well handled served a better purpose than a dozen hastily repaired wounds, since in nearly all the latter cases the patients would die anyway. His paper published in the British Journal of Surgery in 1918 [9] is still a classic of war-time cranial surgery and has been widely quoted by Hugh Cairns, Eldridge Campbell, and others who dealt with battle casualties in World War II.

[8] Cutler, E. C., Military surgery—United States Army—European Theater of Operations, 1944-1945 (Hunterian Lecture), Surg., Gynec. and Obst., vol. 82, p. 261 (March), 1946.

[9] Cushing, H., A study of a series of wounds involving the brain and its enveloping structures, Brit. Journ. Surg., vol. 5, p. 558, (April) 1918.

WORLD WAR II

Introduction of antibiotics.—Between World War I and World War II there were many important contributions useful not only in time of war but for medical and civilian defense. Undoubtedly the most important were the developments in the field of the antibiotics. Much research had been done on them before 1939, but their introduction as therapeutic agents was greatly expedited by World War II. Sir Howard Florey and his resourceful team at Oxford were responsible for establishing the therapeutic potentialities of penicillin. They were the first to isolate it in pure form; they were also responsible for determining its effective dosage and for securing its large-scale commercial production. Several years ago when someone referred to penicillin as an outcome of wartime research Sir Howard protested, and his objections were well taken, for he had begun to work on the antibiotics in the early thirties; but it would have been many years before penicillin could have been made available in large quantities had it not been for the stimulus of war. The story of penicillin has been frequently told and need not be repeated here, particularly since Sir Howard and Lady Florey have recently published detailed monographs [10] in which the meaningful story of the antibiotics has been traced in detail.

Surgery has probably been more benefited by wartime research than any other branch of medicine. In World War I no surgeon would have dreamed of closing an infected wound, or even one that was potentially infected, without leaving a drain. Now, thanks to the use of chemotherapeutic agents such as the sulfonamides and penicillin, it is possible to close wounds of almost every description, even those of the abdomen, without drainage and without fear of subsequent complication from infection, provided all dead tissue has been carefully removed prior to the closure. So great at one time did confidence become in the effectiveness of the new chemotherapeutic agents that some of the younger surgeons grew careless and began closing badly contused wounds without "débridement," i. e., without careful removal of seriously damaged tissue. Such injured areas may be without circulation, and they therefore become the foci of serious infection, since the bloodstream is unable to carry antibacterial agents into such regions. Penicillin thus cannot be regarded as a substitute for good surgery but merely a highly important adjunct. These newer principles of traumatic surgery, as worked out in the war theaters, have had immediate application in all forms of civilian traumatic

[10] Florey, H. W., Antibiotics: a survey of penicillin, streptomycin and other antimicrobial substances from fungi, actinomycetes, bacteria, and plants, 2 vols., London, 1949; and Florey, M. E., The clinical application of antibiotics: Penicillin, London, 1952.

surgery, and they are rapidly being adopted in our surgical clinics, largely through the influence of the younger medical officers returning from active service.

A second important result of the use of penicillin and the sulfonamides has been the avoidance of unnecessary amputations and unnecessary removal of potentially viable tissue. With the greater confidence that these drugs are bringing to the surgeon he is able to operate much less radically. Formerly it was taught that all contused tissue should be removed from an injured area, but a contused muscle may still have an active circulation and therefore be capable of regaining its normal function. When the thigh muscle or the calf has been injured by a high-velocity missile, the muscle is generally contused over a large area, and a surgeon of the old school would in most such instances amputate rather than risk secondary infection. During the last 2 years of World War II and during the Korean campaign countless extremities injured in this manner have been saved by combining penicillin therapy with conservative surgery. One of the burning arguments, however, that one still encounters in surgical amphitheaters turns on the criterion of tissue viability: how can a surgeon be certain that a contused muscle will recover its function? The old adage ran, "When in doubt, remove it"; a newer epigram might be, "If it bleeds, it can recover," and "When in doubt, leave it."

BLOOD FRACTIONATION

Surgery has also been influenced by wartime studies on human blood and the blood plasma fractions that have become available in pure form, again as a direct result of wartime medical research. At the beginning of the war, much effort was devoted to the preparation of blood fractions suitable for transfusion. Blood plasma (whole blood minus the red blood cells) was made available, but since many untoward reactions occurred from the transfusion of incompatible plasmas, and since under war conditions blood typing was often difficult or impossible, the plasma proteins were fractionated and the globulin fraction that carries the allergic potentialities of the blood was eliminated, leaving the albumins and fibrinogen. Albumin was then prepared in pure form and was thus made available for immediate transfusion without fear of complications.

It soon became obvious, and this should have been clear from our experience in World War I, that when men have sustained severe hemorrhage whole blood is needed for transfusion, not merely plasma or albumin, since many weeks are required for the body to regenerate its red blood cells. The British had attempted to collect and store whole blood in 1939, but their efforts were largely unsuccessful because of difficulties in preservation. In 1943 an effective preservative was

developed by the United States National Research Council, and within a few months whole blood was being flown in enormous quantities to Europe as well as to all the outposts of our Pacific theater, as it is now being flown to Korea. So effective is this service that blood drawn on the west coast was delivered in refrigerated containers less than 48 hours later at points such as Leyte, and at the end of the war it was quickly reaching Seoul and other points in the Korean theater.

As a result of these investigations on blood and its fractions, the civilian surgeon has an imposing array of blood substitutes ready for his use at any time, and he is able to count on a supply of stored whole blood rather than having to find a blood donor at the scene of an accident or at some outpost of civilization. He has also come to depend on two other significant blood fractions, namely, fibrin and thrombin, which, thanks to the work of Edwin Cohn, Franc Ingraham, and others, are available in pure form, and in combination can be used to stop the most stubborn hemorrhage, e. g., bleeding from the brain substance or the liver, which is notoriously difficult to arrest. A more homely use of the fibrin-thrombin combination is for stopping a nosebleed or the hemorrhage that so often follows tooth extraction.

Important new branches of medicine, important to the armed forces and to civilians alike, have been created by wartime necessity. Although no word has yet been coined to cover the great new area of chemical applications in disease control, i. e., insect repellents, insecticides, and antimalarials, which are now numerous because of our attempts to make military operations possible in tropical regions, this special field presents itself as a new and discrete branch of medicine and should be so recognized. Just as Maj. Walter Reed and Gen. William C. Gorgas made possible the building of the Panama Canal through control of yellow fever, so the repellents (against insect and shark) and the new insecticides made possible operations in the South Pacific in World War II that otherwise would have been too costly to contemplate. Other new and significant branches that have developed are aviation and submarine medicine.

AVIATION MEDICINE

Oxygen administration.—Progress in aviation, stimulated by developments in military aircraft, has led to many advances of outstanding value both for medical defense and for civilian aviation.[11] One of

[11] Hoff, E. C., and Fulton, J. F., A bibliography of aviation medicine, Springfield, Ill., 1942. Hoff, P. M.; Hoff, E. C.; and Fulton, J. F., A bibliography of aviation medicine: Supplement, Springfield, Ill., 1944. Fulton, J. F.; Hoff, P. M.; and Perkins, H. T., A bibliography of visual literature, 1939–1944, Washington, D. C., 1945.

these is oxygen administration. During the First World War, few fighter planes could achieve altitudes greater than 18,000 feet, and the use of oxygen, except in unusual instances, was not deemed a prime military necessity; hence, such oxygen masks as there were were crude in design and wasteful from the point of view of oxygen supply. The need for oxygen masks was well known, however, from early balloon ascents, and particularly from the tragic Tissandier disaster, which occurred on April 15, 1875. Three men had ascended in a balloon to an altitude of 28,000 feet, and all three were overcome by altitude sickness before they could breathe the oxygen they had on board. As a result, two of the balloonists, Crocé-Spinelli and Sivel, succumbed, and Tissandier alone of the three survived. The intrepid French experimenter, Paul Bert, established the fact in a home-made pressure chamber that it was not low pressure as such that had caused the death of the two balloonists but rather the low pressure of oxygen at 28,000 feet. Paul Bert exposed himself, along with a bird and a rat, to a pressure of 430 mm. Hg. The bird vomited and appeared quite sick, and at a slightly higher altitude the bird was close to death and the rat uneasy. At that point, Professor Bert became dizzy and his pulse had increased from 60 to 86. He then began to breathe oxygen, his dizziness disappeared, and his pulse within 2 minutes had dropped to 64, but it was still impossible for him to whistle. He continued his ascent to an altitude equivalent of 29,000 feet (428 mm. Hg), at which time the bird was prostrate and a burning candle had turned very blue, with its flame almost extinguished.

This celebrated experiment made it quite clear that oxygen must be available if planes without pressure cabins were to ascend to altitudes above 18,000 feet. Further study carried out during World War II made it clear that vision, mental alertness, and the capacity to fly a plane with safety began to diminish at altitudes as low as 5,000 feet, this being particularly true of night vision. Hence, when military aircraft began to ascend to altitudes of 25,000 and 30,000 feet and later to 40,000 and 50,000 feet [12] the problem of oxygen supply became acute and all the problems worked out for military aircraft were immediately applicable to commercial planes carrying civilians. It has been said that the Battle of Britain was won with a few oxygen masks. In a literal sense this is perhaps true, because Hitler's military pilots, both fighters and bombers, began in the summer of 1940 to come in at altitude ceilings well above the tolerance of an ordinary flier and they had developed systems of oxygen supply that for a brief

[12] In the *Illustrated London News* for May 16, 1953, it is reported that on May 4 a new English turbojet bomber (Canberra type) reached an authenticated altitude of 63,668 feet, which stands as the altitude record for heavier-than-air machines under human control.

time were superior to those of British fighters. Thanks to the efforts of the Flying Personnel Research Committee and particularly to one of its members, Sir Brian Matthews, the British developed a successful oxygen mask and a system of supply that made it possible for British fighters to meet German raiders at their own altitude, and through this circumstance the Battle of Britain was won, virtually in a single day, September 15, 1940, when 186 German planes were shot down. The Luftwaffe quickly decided it could no longer stand this rate of attrition. The British were tireless in their efforts to improve their oxygen masks and modes of supply, and our own air forces profited immeasurably by British experience, which was made freely available to the U. S. Army and Navy Air Forces.

Pressure-cabin aircraft.[13]—It early became obvious to some investigators, including Paul Bert, that, if the gondola of a high-altitude balloon were artificially pressurized, a balloon might ascend higher into the atmosphere without endangering life. But years passed, and it was not until 1933 that the National Geographic-United States Army stratosphere flight was able to make an ascent in a pressurized gondola with adequate pressure control. In this memorable ascent, Auguste Piccard achieved an altitude of 72,395 feet, the highest altitude yet attained by man.

The experience encouraged the United States Army Air Corps to think of pressurized combat aircraft, and to Harry G. Armstrong, now Surgeon General of the United States Army Air Forces, must be given credit for having, through a historic Air Corps technical report, outlined the physiological requirements of sealed high-altitude aircraft compartments. This was a starting point for developments of pressurized planes in this country, the first of which (the XC–35) was flown in April 1937. In this development the United States was ahead of both Britain and Germany and, thanks to the enterprise of the Lockheed Aircraft Corp., finally succeeded in making their stratoliners (B–307) and Constellations effectively pressurized. After 1946 Constellations began to make regular transatlantic flights at altitudes ranging from 18,000 to 24,000 feet, while the pressure in the cabins was maintained at an average corresponding to 8,000 feet.

Technical difficulties in pressure-cabin aircraft prove numerous, and for the most part they stem from man's physiological requirements, i. e., maintaining cabin pressure, and, of almost equal importance, adequate ventilation. The average air passenger, without lung or heart

[13] The material in this and the following section is based on Fulton, J. F., Aviation medicine in its preventive aspects: An historical survey (Heath Clark Lectures, 1947), London, 1948. National Research Council, Decompression sickness, caisson sickness, diver's and flier's bends, and related syndromes, Philadelphia, 1951.

disease and under the age of 70, is quite comfortable at an altitude of 8,000 feet, even though at that height his night vision may be somewhat impaired. But ventilation of the fuselage presents a very real problem because of the accumulation of water vapor and carbon dioxide; also in hot weather body odors and fumes from aircraft instruments and engines demand rapid change of air at appropriate pressure. In a completely sealed cabin a change of air of 2 to 3 cubic feet per minute per person will keep the humidity and the carbon dioxide at a tolerable level, provided there are no exhaust fumes.[14] Leaks in the pressure-cabin equipment are inevitable, however, and with further experience it became evident that a change of at least 12 cubic feet per minute per person would be essential for comfortable air travel. This involved installation of larger turbopressurizers and air coolers to make the pressurized air tolerable from a thermal standpoint. Through experience gained during World War II these difficulties have now been largely overcome, and essential equipment has now been installed in all long-range, high-flying, pressurized passenger aircraft.

Explosive decompression.—An ever-present hazard in pressurized aircraft, both military and commercial, is that of sudden or explosive decompression. Pressurized aircraft, such as the Constellation, is stressed to withstand a pressure differential of 6.5 pounds per square inch. This would permit flight at 30,000 feet with an internal pressure equivalent of 8,000 feet. If a large military aircraft, flying at 30,000 feet, were suddenly depressurized by enemy action, the pilot, if he had oxygen available, could carry on, but other crew and passengers without oxygen would retain useful consciousness for about 2 minutes. If no oxygen were available, crew and passengers would become unconscious within a matter of minutes and death might ensue within a period of 8 to 10 minutes. Hence, commercial planes, in which explosive decompression might occur as a result of the breaking of a window, failure of turbos, or explosion of an observation dome, are not permitted to fly above 22,000 to 24,000 feet, since a large plane cannot descend rapidly enough to insure consciousness of the occupants, especially of the crew.

With military planes, which ascend to much greater altitudes, the situation is even more critical. For example, if pressurized military aircraft were flying at 52,000 feet and were suddenly decompressed, the pilot would have only 15 to 20 seconds to get himself out of the plane, and, if he did not descend within 3 to 5 minutes through free fall to 20,000 feet, his heart would have stopped. A direct pressure dive might enable the pilot to achieve 15,000–20,000 feet, but he would

[14] Spealman, C. R., Aviation toxicology (an introduction to the subject and a handbook of data), New York, 1953.

be unconscious when he reached that level. In view of this circumstance it has been deemed safer to bail out for a free fall with a parachute that will automatically open at 10,000 to 12,000 feet. With rockets and the much-talked-of space ship, which will fly through ether in which there is no pressure and no oxygen, the paramount importance of maintaining adequate pressure levels is obvious, and the energy required to maintain pressure, let alone jet propulsion, is so great that even the most optimistic are loath to predict that the problem of fuel supply could be solved, despite all the resources of human ingenuity, within the life span of this generation. Perhaps one might reach the moon, but how would energy be secured to insure return? More difficult conundrums have been solved in the past, but, although I happen to be an optimist with faith in the resourcefulness of some future generation, I believe that the only possible solution lies in atomic energy with all its weighty paraphernalia.[15]

Acceleration in high-speed aircraft.—The successful use of oxygen presupposes a steady blood circulation without undue gravitational pressure on the heart; however, it became obvious to the French flight surgeons in 1918 that rapid turns and dive pull-outs tended to diminish the flow of flood to the brain. In the Snyder Trophy Races in 1929, confusion and dimming of vision were encountered when the pilots were rounding the pylon; and in 1932 a man of great insight, Heinrich von Diringshofen of the German Air Ministry Research Laboratories at Tempelhof in Berlin, constructed a human centrifuge to simulate problems of acceleration in flight. Before this, however, two equally thoughtful Dutch investigators, Jongbloed and Noyons of Utrecht, had studied the effects of acceleration on the level of the systolic blood pressure in animals. As a plane's speed is augmented or diminished, the pilot is pushed backward or forward in his seat by a force directly proportional to the rate of acceleration or deceleration. If the increase of speed occurs at 32.2 feet per second, the pilot would be pushed against the back of his seat by a force equal to that of gravity, but, when pilots pull out of dive-bomb maneuvers, the direction of the acceleration is from head to foot, and, as far as the circulation is concerned, there is a tendency to pull blood from the head.

Need for protection from high acceleration in aircraft has become even more acute in the last few years owing to the development of the

[15] And so it turns out that in man's quest for mastery of the air a great step forward has been taken in the successful development of pressurized cabins. These developments, however, are in their early infancy from the engineering standpoint, and their use in larger transport planes, in rockets and jet-propelled craft, will succeed only if the limitations of the human frame, both in its structure and in its functions, are kept constantly in mind. And let us not forget that it was a flight surgeon and not an engineer who wrote the specifications for the first pressurized plane. [See Fulton, footnote 13.]

fast-flying jet plane and the possibility of using rockets for human transportation. Even when planes were unable to fly at rates of more than 200 to 300 miles per hour, acceleration had become a vital problem, especially in dive bombers, and in fighter aircraft that were able to make fast turns. Now that jets are achieving speeds of 500 to 700 miles per hour, the need for protection from acceleration is vastly increased. The pneumatic pressure suit developed by Capt. John Poppen, USN (MC), Prof. F. A. S. Cotton in Australia, and Dr. Harold Lamport in New Haven, Conn., and many others, has served to give measurable and strategically significant protection for military pilots. Such suits have proved of inestimable value, especially during the D-day operations, and more recently for our fighter pilots in Korea.

Design for safety.—During the war there were many instances in which a fast-flying bombing plane crashed into a mountain side and everyone on the plane, except for the tail gunner, was instantly killed. Accidents such as this have stirred inquiry into the reasons for these apparently miraculous survivals. They lie in the fact that the rear gunner's head and the rest of his body were supported by solid structure at the time of the impact and in the fact that he was riding backward. Those situated in a more forward position in a crashing airplane are thrown from their seats because of insufficient strength of seat belts and seat moorings, and according to the wartime report of Whittingham, director general of medical services of the R. A. F. (and now of B. O. A. C.), 95 percent of the deaths in air crashes result from head injury, i. e., the head of the passenger is thrown violently against solid structure.

It became obvious, in view of episodes such as these, that rear-facing, heavily moored seats would confer a degree of passenger safety at least 10 times as great as that which could be achieved with forward-facing seats with fragile seat belts to hold the passenger in place in the event of accident. The British public and airplane manufacturers have already seen the virtue of rear-facing seats, and many of their new passenger planes are so equipped. In the United States the resistance on the part of both the flying public, and more particularly the aircraft designers, has been so great that to date only Northwest Airlines have seen fit to install rear-facing seats in commercial craft.

The principles involved in the greater safety from rear-facing seats are simple. If one falls to the ground and strikes one's head on soft earth, the head is decelerated in a matter of a few tenths to one-half a second; the blow being thus softened, the accident victim may not suffer concussion or unconsciousness. When, however, a person knocked off a bicycle strikes his head on solid cement that does not yield, he may suffer fracture of the skull, concussion, hemorrhage, and possibly even death. In these circumstances the head is decelerated in a matter of

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a hundredth of a second or less, depending on whether the falling person has on his head a soft felt hat or a football helmet. Crash helmets to minimize sudden deceleration of the head are now in use in almost every military aircraft, since pilots, unfortunately, are unable to occupy rear-facing seats with present flight equipment.

Hugh De Haven, director of crash injury research at Cornell University Medical College in New York, is, among others, responsible for stressing these considerations. In this connection, one of his most impressive studies has been the analysis of nonfatal suicide leaps in the city of New York. Persons have survived virtually uninjured after leaps from the tenth and even the seventeenth floor of New York buildings, and, when the circumstances are analyzed in any given case, it turns out that the intended suicide victim has usually landed flat on his back in a soft garden plot or on a ventilating screen, or his fall may have been broken by awnings or an automobile top. This again indicates the importance of gradual rather than abrupt deceleration. These principles have proved to be immediately applicable not only in aircraft design but also in the automotive industry. A summary of these considerations has been given in Hugh De Haven's "Development of Crash-survival Design in Personal, Executive and Agricultural Aircraft." [16]

The literature of aviation medicine, the great part of which has come from military installations, affords many other examples of material that is immediately applicable to commercial aircraft and to the automotive industry. It stresses the importance of having men of vision, imagination, determination, and sound training in the medical departments of all our military services, for the contributions they make are likely to be of importance not only to military operations but to society in the broadest sense.

SUBMARINE MEDICINE

Submarine medicine offers many examples of scientific disclosures with general application, but they are of less immediate significance to the civilian public at the present time, since it is not much given to traveling in submersibles, except for a few hardy souls such as William Beebe, who study marine life at great depths in the sea, and the "frogmen," who do mysterious things at depths of 100 or more feet in the interests of national defense. Of course, the diver and the caisson worker can always learn much from submarine experience, especially about protection from caisson disease and diver's "bends." There is no journal of submarine medicine, but the physiological prob-

[16] Crash Injury Research, Cornell University Medical College, New York, (May) 1953.

lems encountered by submarine personnel are numerous and the literature pertaining thereto has been analyzed, summarized, and systematically arranged in a remarkable bibliography by Commander Ebbe C. Hoff, USNR (MC) entitled "A Bibliographical Sourcebook of Compressed Air, Diving and Submarine Medicine," published by the Navy Department in February, 1948. The bibliography contains nearly 3,000 entries, each of which is summarized and reviewed in subject groups. It does not fall within the scope of this paper to discuss the technical phases of submarine medicine but attention should be directed to K. E. Schaefer's comprehensive monograph (826 pp.) on German submarine medicine.[17] Dr. Schaefer, chief of the Submarine Physiological Laboratory at Heidelberg during the war, is now continuing his important studies in the physiology branch of the United States Naval Medical Research Laboratories at New London, Conn. His recent reports from the submarine base should also be consulted.

In closing this historical survey on the importance of military medicine to national and civilian defense I can do no better than to quote the words of Capt. J. S. Taylor, USA(MC), written after World War I:[18]

> The world is far from even apprehending what it has yet to learn thoroughly, that in the field the distribution of medical supplies, prompt evacuation, skillful first aid, shelter, food, and restoratives available early for every fallen combatant are of infinitely more importance than highly technical relief to difficult cases. More critical still are the problems relating to later demobilization, to hospitalization and rehabilitation of war victims, and the faithful but well-ordered and economical relief of the wreckage of war. Millions will be spent and more millions wasted until the time comes when it is a recognized part of the program of national defense to organize methods of post bellum relief at the same time that activities are initiated for the prosecution of hostilities. We have progressed from the day of medical attendance for leaders to medical attendance for all combatants, and leaders are increasingly alive to the immediate necessary needs of their forces; but we have not yet attained to a comprehensive grasp of the requirements or possibilities of military medicine.

[17] Schaefer, K. E., Symposium on submarine medicine, U. S. Fleet Naval Forces, Technical Section (Medical), Germany, 1950.

[18] Taylor, J. S., A retrospect of naval and military medicine, U. S. Naval Med. Bull. 15, No. 3, p. 608, 1921.

Harriet Lane Johnston and the National Collection of Fine Arts

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[With 8 plates]

A CONTINUING RESPONSIBILITY of the National Collection of Fine Arts is the preservation of a permanent collection valued at over $10 million. For the establishment of this large assemblage of paintings, sculptures, and decorative art objects under a separate bureau of the Smithsonian Institution, the United States is especially indebted to Harriet Lane Johnston, niece of James Buchanan, the fifteenth President of the United States, and hostess at the White House during his Administration.

At her death in 1903 Harriet Johnston bequeathed her precious mementos, historical objects, and famous pictures with the understanding that they should be placed in the Corcoran Gallery of Art until the founding of a national gallery, when they should become the property of the Nation. These provisions in her last will and testament raised questions for court decision, and in 1906 Justice Wendell P. Stafford of the United States District Court of the District of Columbia decreed that the Smithsonian Institution was in fact the legal repository for Government-owned works of art within the meaning of her will and, therefore, the rightful recipient of her treasures. They were placed in custody of Dr. William Henry Holmes, but not until 1920 did Congress appropriate funds for salary and assistance that led to his appointment as director of what is now the National Collection of Fine Arts.

Until the terms of the Johnston will were carried out, Government art collections were limited to scattered early gifts. The John Varden collection had been transferred with that of the National Institute, at the latter's expiration in 1861, to the Smithsonian Institution after Buchanan had left the White House and Harriet Lane had gone with him to Wheatlands, his Lancaster, Pa., estate. These accessions, together with paintings and sculptures acquired unsystematically during the remainder of the nineteenth century, were so dispersed as to barely deserve the impressive title her bequest invoked. Her vision

inspired action, and her gift was followed by those of connoisseur-industrialist Charles L. Freer, businessman William T. Evans, and lawyer Ralph Cross Johnson. Crowded by later additions to the permanent exhibition, the significance of her collection had been all but forgotten. In the reorganization of the gallery in 1953, its importance was recognized anew, and it was then restored to primary position at the head of the arrayed collections. Gentle, gracious, and most favored in her youthful leadership in Washington, Harriet Lane Johnston commands our gratitude today as First Lady of the National Collection of Fine Arts.

Born in Franklin County, Pa., in 1830, Harriet Lane was the youngest of several children orphaned by the death of Elliot T. Lane and his wife Jane. At the age of 9 Harriet showed wisdom in the choice of her mother's brother, James Buchanan, as her guardian. A bond of affection developed between niece and uncle, then Senator from Pennsylvania, that inspired two fine characters to lives of distinction in national service. Harriet, in gaining his devoted guardianship, required of him the solicitude of a bachelor tragically disappointed in love. He had suffered a broken engagement resulting from misunderstanding, and his beloved had died before reconciliation. She was known to Harriet through a miniature, a careful tracing of which, with tender notations, was long treasured and now reposes in the Library of Congress with her letters. Understanding of each other's loss seems to have kindled an unwavering loyalty that lasted to the end of his long career as statesman and President, the full worth of which is yet to be appropriately acknowledged by historians. No daughter could have rewarded more steadfastly in later years the watchful guidance he provided in the period that demanded greatest effort in his own behalf. Harriet Lane enjoyed physical vigor and personal charm that proved equal to responsibilities and opportunities rarely faced by an American girl. Fortune was not always kind, yet hers was ever a willing acceptance and happy response, which enabled her to surmount trials with faith and grace, to win the unreserved admiration of all who knew her.

Letters to his adopted niece reveal certain fears James Buchanan held that animal spirits and tomboy inclinations would pose problems in rearing his young ward. The rising statesman knew how to blend official authority with an uncle's affection. Rarely did he reprimand without pointing out reward for good behavior. He admonished her in his letter to her of March 20, 1843, "How proud and happy I should be to acknowledge and cherish you as an object of deep affection could I say, she is kind in heart, amiable in temper and behaves in such a manner as to secure the affection and esteem of all around her."[1] Such words were a steadying influence during days at the fashionable

[1] Curtis, George Ticknor, Life of James Buchanan, 2 vols. New York, 1883.

boarding school in Charlestown, in what is now West Virginia, which she attended with her older sister Mary. After three years there between the ages of 12 and 15, she was enrolled at the old Georgetown Convent of the Visitation. Her Senator uncle felt no fear that she might become a nun, but expected her to be taught "charity and sympathy for all God's people." From Wheatland he wrote admonishing her for her lack of application to her studies; but when, in her last two years, she won high honors, he took great pride in her achievement.

Hers was the beauty of golden hair and bright blue eyes. Buchanan cautioned his attractive niece never to marry "if not attached" nor with a man unable "to afford decent and immediate support." He warned her to let flattery "pass in one ear gracefully and out the other." His kindness and concern were shown when his proposed appointment as Minister to Great Britain threatened separation. He wrote, "I think that a visit to Europe with me as Minister would spoil you outright. Besides, it would consume your little independence. One grave objection to my acceptance of the mission, for which I have no personal inclination, would be your situation. I should dislike to leave you behind, in the care of any person I know." The post, however, was accepted, and Harriet's elation at the prospect of accompanying him was cooled by a period of waiting during which she was assured that her "beautiful dream" would be "disappointing in reality." On April 29, 1854, Harriet left New York for London in the company of Mrs. Perry, wife of the Commodore. On the advice of her uncle, she brought "no New York dresses as ladies [there] of highest rank do not dress as expensively as in the U. S."

Buchanan's years of experience as a statesman gave him great poise and dignity. He became a favorite at the Court of St. James's, and his niece's popularity added to his own. Queen Victoria bestowed upon her more honors than were accorded any other foreign woman. Harriet described to her sister Mary the regal dinners she enjoyed at the Palace in her uncle's company, her dancing with the Prince of Wales, and conquests of the heart of more than one wealthy British peer. Her success socially in the aristocratic English Court gave her the self-confidence that was to prove such an asset to her later as First Lady of the White House.

In an effort to keep her from becoming too vain, the ever watchful guardian said to his niece, upon their return from the second Drawing Room of 1854 Season, "Well, a person would have supposed you were a great beauty, to have heard the way you were talked of today. I was asked if we had many such handsome ladies in America. I answered yes and many much handsomer. She would scarcely be remarked there for her beauty." [2]

[2] Hostetter, Ida L. K., Harriet Lane, Lancaster, Pa. Lancaster County Hist. Soc. Pap., vol. 33, No. 6, 1929.

The Honorable James MacGregor was one of many Englishmen whose friendship for James Buchanan and his niece outlasted the Pennsylvanian's official duties there. This member of the English Parliament expressed his admiration of the American Minister by the gift of an engraved portrait of Sir John Hampden, cousin of Oliver Cromwell and cochampion in Parliament against illegal taxation of citizens by the crown. This portrait is among the mementos of Buchanan's ministry to England, now in the National Collection of Fine Arts.

Harriet returned to the United States in October 1855. The following spring her uncle became a third-time candidate for the presidential nomination. The gavel used at the Democratic Convention in Cincinnati which gave him the nomination on June 19, 1856, is to be seen in the collection. Harriet was 26 when he won the election in the fall.

Miss Lane served as President Buchanan's official hostess until Lincoln's inauguration. Through times of gravest national anxiety she maintained at the White House an atmosphere of serenity and cordial warmth that aided Buchanan's attempts to insure a period of good feeling. The friendship between the White House and the Court of St. James's assumed historical importance when later it offset, to some extent, English sympathy for Southern suppliers of British cotton mills. When the Princess Royal of Great Britain was married, President Buchanan received a letter from her father, Prince Albert, dated February 16, 1858, expressing his warm personal regard for the President, and a silver medal struck in commemoration of the marriage.

The laying of the transatlantic cable and the opening up of telegraphic communication with Great Britain furthered the pleasant relations between the Queen of England and the former Minister to her Court. The original copy of the official congratulations exchanged on August 17, 1858, between Victoria and James Buchanan was for years in the possession of the President's nephew and confidential secretary, J. Buchanan Henry, and afterward became a part of the Harriet Lane Johnston collection, where it may now be seen as first matted and framed.

Harriet's spontaneous gaiety enlivened grand occasions. A 5-day visit from Albert Edward, Prince of Wales, in October 1860 called for the utmost in White House entertainment. The climax of the festivities was an excursion aboard the Revenue Service Cutter "Harriet Lane" (named for the President's niece by the Secretary of the Treasury Howell Cobb) to Mount Vernon where the Prince and his entourage, accompanied by the President, his niece and his Cabinet, saw Washington's tomb. This was pictured by Thomas Pritchard Rossiter (1818–1871) in a painting preserved in the collection. An-



Harriet Lane Johnston, by John Henry Brown (1818–1891). Watercolor on ivory, 4½ x 3⅝ inches.



Portrait of the Prince of Wales (King Edward VII), by Sir John Watson Gordon (1798–1864). Oil on canvas, 50 x 40 inches.



James Buchanan Johnston, by Harper Pennington (1854–1920). Oil on canvas, 29½ x 18½ inches.



1. Harriet Lane Johnston, by William Henry Rinehart (1825–1874). Marble, height 28 inches.



2. James Buchanan, by Henry Dexter (1806–1876). Marble, height 25 inches



Henry Elliott Johnston, Jr., as "Cupid Stringing His Bow," by William Henry Rinehart (1825–1874). Marble, height 42½ inches.



1. Miss Kirkpatrick, by George Romney (1734–1802). Oil on canvas, 30 x 25 inches.



2. Josepha Boegart, attributed to Franz Pourbus (1569–1622). Oil on wood, 24¾ x 19½ inches.



"Independence," by Frank B. Mayer (1827–1899). Oil on mill board, 12 x 15⅞ inches.



1. Mrs. Abington, by John Hoppner (1758–1810). Oil on canvas, 30 x 25 inches.



2. Mrs. Hammond, by Sir Joshua Reynolds (1723–1792). Oil on canvas, 30 3/16 x 25 1/8 inches.

other souvenir of the sojourn of the Prince, long before he became King Edward VII, is a portrait in uniform painted by Sir John Watson Gordon (1798–1864). It was given to President Buchanan in 1862, and is described in the letter from Jaffa, Palestine, exhibited with the painting, "as a slight mark of [his] grateful recollection of the hospitable reception and agreeable visit at the White House."

Letters exchanged by Queen Victoria and the President in connection with the visit of the Prince of Wales bear evidence of the cordial relations existing between England's ruler and the head of our Government. This friendship with the Royal Family was maintained by Harriet Lane Johnston to the end of the Queen's long reign, as evidenced by the collection's photograph of Victoria, autographed in 1898, and an invitation to Edward VII's coronation in 1902 known to have been received from the King.

As early as 1853 Buchanan had written his niece, "It is my desire to see you happily married, because, should I be called away, your situation would not be agreeable I desire that you shall exercise your own deliberate choice of a husband. View steadily all the consequences, ask the guidance of Heaven, and make up your own mind and I shall be satisfied." Though a host of suitors hovered about constantly and romance often beckoned, Harriet seemed too preoccupied with her household and official duties to think of marriage. But in Lancaster during October 1865 she obtained her uncle's cheerful approval of her acceptance of Henry Elliott Johnston. "You have made your own unbiased choice and from the character of Mr. Johnston I anticipate for you a happy marriage," he wrote, and, the decision having been made, he cautioned her against unreasonable delays.

After 6 years with her uncle in his last retirement to Wheatlands, she became the bride of the suitor whose devotion had been constant since they first met in early youth at Bedford Springs. She went to the Maryland home of her husband, who was a junior member of a Baltimore law firm. Her happiness was marred 2 years later by the loss of her beloved uncle. Two sons were taken from her at ages 12 and 14; and then she lost her husband after 18 years together. The American sculptors Henry Dexter (1806–1876) and William Henry Rinehart (1825–1874) have transmuted to marble the physical likenesses of the distinguished ex-President, his niece, her husband, and the latter's namesake. The last mentioned is shown at the age of two as "Cupid Stringing his Bow." The older son, James Buchanan Johnston, is the subject of the posthumous portrait by Harper Pennington (1854–1920).

The remainder of her life in Baltimore and Washington she spent quietly with plans ever in mind for worthwhile memorials to her loved ones. The birthplace of Buchanan in Mercersburg, Pa., St.

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Albans and the Cathedral Choir School in Washington, the hospital wing bearing her name at Johns Hopkins, and the Harriet Lane Home for Invalid Children in Baltimore are outstanding among her generous benefactions.

Though not a memorial gift, the Harriet Lane Johnston Collection very appropriately commemorates in Washington the exemplary public lives of both its gracious donor and her gallant guardian. In addition to the memorabilia, paintings, and sculptures already mentioned, the following are noteworthy. The Italian Renaissance is represented by Bernardino Luini's (c. 1450–1535) "Madonna and Child," and the Dutch and Flemish of a century later by Franz Pourbus's (1569–1622) "Josepha Boegart," more English than Belgian in appearance. There is also a portrait of Harriet's continental companion, Madame Tulp, by the Dutch painter Jansen Van Ceulen (1593–1661). Paintings of English ladies were sought for the walls of her stately parlors as agreeable reminders of the tour of duty in Great Britain. Portraits of Mrs. Hammond, by Reynolds (1723–1792); Mrs. Abington, by Hoppner (1758–1810); and Miss Kirkpatrick, by Romney (1734–1802), have found places with Lady Essex, by Lawrence (1769–1830). The identity of the subject of a portrait by Sir William Beechey (1753–1839) as Miss Agnes Murray has not yet been positively established. Her costume, restored through the removal of later repainting, is in the style of the period in which the artist painted her.

The American paintings are few aside from "Independence," a genre subject by F. B. Mayer (1827–1899), Maryland historical painter who recorded this scene of easy life in Frostburg. The portrait of James Buchanan by Jacob Eicholtz (1776–1842), painted between his last year as Representative from Pennsylvania and the time he became American Minister at the Russian Court in St. Petersburg, is of historical importance. It shows Buchanan as he appeared about the time his favorite niece, Harriet Lane, was born. He and the niece were portrayed again in later life by J. Henry Brown. This artist had made a miniature of Buchanan in 1851, and in 1876 he was asked by Henry E. Johnston, husband of the ex-President's niece, to duplicate it for her. The artist painted a new picture from daguerreotypes instead of copying the earlier picture. Its companion-piece, a miniature of the donor of the Harriet Lane Johnston collection, is an exquisitely rendered portrayal of matronly beauty. At 43 years of age, Harriet Lane Johnston was a queenly figure, combining gentleness and feminine charm with the majestic mien of a woman fully aware of her trusteeship of the mementos of a golden epoch in White House history and conscious of the importance of art to the Nation's future.

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